INSTRUCTION MANUAL

Gertsch*

MODEL CRB-8
COMPLEX RATIO BRIDGE
MAINTENANCE

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Precision electrical and electronic instruments for measurement

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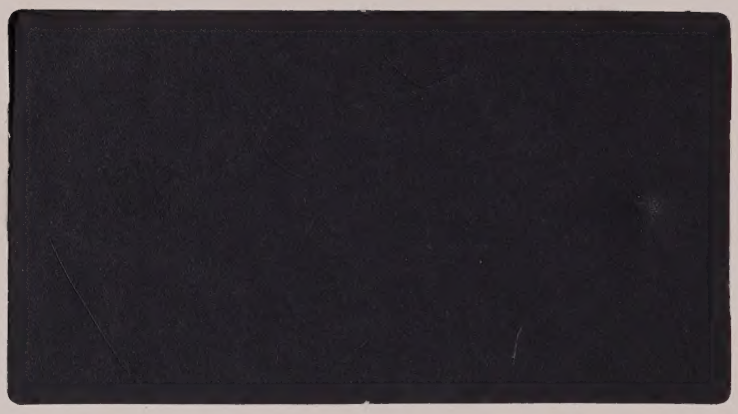

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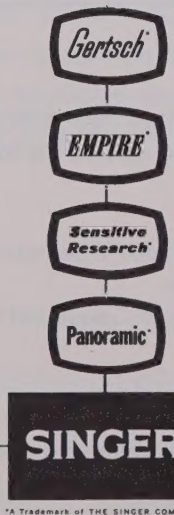

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1. Model or Type
2. Serial Number
3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
6. Approximate number of hours of use
7. Has maintenance action been previously requested?
8. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.

(1) Contact Metrics Division, Bridgeport, Connecticut for *Commander**, *Empire**, *Panoramic**, and *Sensitive Research** instruments. Contact Metrics Division, Los Angeles, California for *Gertsch** instruments.

(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

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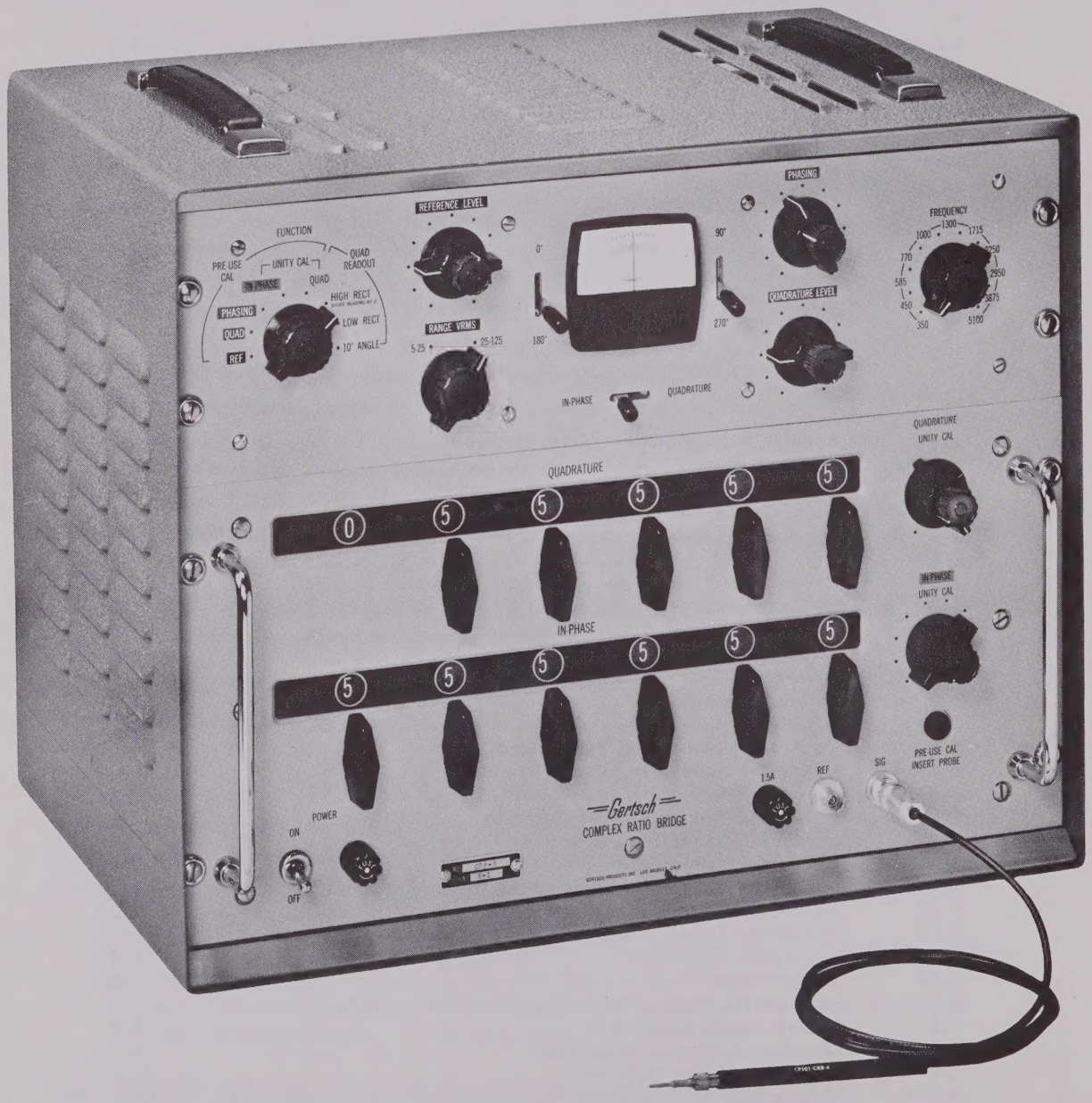

Figure 1-1. Model CRB-8 Complex Ratio Bridge

SECTION I
GENERAL DESCRIPTION

1-1. PURPOSE.

1-2. The Gertsch Model CRB-8 Complex Ratio Bridge measures phase and amplitude relationships between the input and output signal voltages of a unit under test. The signals are compared and their relationships are indicated either as a complex vector ratio (± in-phase ratio ± quadrature ratio) or as an in-phase ratio plus phase angle directly in degrees.

1-3. DESCRIPTION.

1-4. The bridge uses the input signal of the unit under test as a reference voltage and the output of the unit under test as a signal input. With the reference voltage operating as a source, an internal voltage is selected by a six decade ratio transformer (Ratiotran*). When the internal voltage exactly equals the signal input voltage, a phase sensitive null detector, operating on an AC bridge principle, indicates a null. A null amplifier, consisting of a tuned preamplifier and a high gain amplifier, drives the null detector circuit so that minute values of off-null voltage can be detected. At null, the setting of the ratio transformer indicates the in-phase ratio between the two input signals.

1-5. Any phase shift through the unit under test introduces a quadrature component into the output signal which can cause erroneous measurements by obscuring the in-phase null point. To eliminate this effect, a second ratio transformer is used to null out the quadrature component. A portion of the reference voltage is shifted through 90° and operates as the source for this ratio transformer. At null, the setting of this ratio transformer indicates either the quadrature ratio or the phase angle.

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1-6. Harmonic voltages and noise, generated by the unit under test, can also obscure the null. The tuned preamplifier of the null amplifier reduces the noise and harmonic components of the null voltage to a minimum. The noise and harmonic content of the input signal can be measured at a special connector, accessible from the back of the unit.

1-7. To indicate complex ratios or phase angles in all four quadrants, two switches are provided. One switch allows the in-phase portion to be inverted for measurements in the second and third quadrants. The second switch allows the quadrature portion to be inverted for measurements in the third or fourth quadrants. Through proper selection of switch positions, the complex vector ratio or phase angle can be determined regardless of phase differences between the reference and signal voltages.

1-8. Through the use of front panel tuning controls, the bridge can be tuned to any frequency in the 360 to 5100 cps range. No plug-in filters or networks are used.

1-9. Isolation of the unit under test is accomplished by an isolation amplifier which produces an input impedance of at least 20,000 megohms at null. This feature virtually eliminates loading errors and ground loop problems. to further reduce ground loop problems, the signal circuits may be completely isolated from case ground.

1-10. The ratio bridge is a self-contained unit which can be mounted in a standard Gertsch carrying case or fitted into a standard 19 inch relay rack. The unit may be converted for use with 115 or 230 vac power by simply operating a switch and replacing a fuse.

1-11. All operating controls, indicators, and test connectors are mounted on the front panel. No auxiliary equipment is required for pre-use adjustments or operation.

TABLE I. SPECIFICATIONS

FREQUENCY RANGE:
350 to 5100 cps continuous

ACCURACY:
In-phase
Rectangular Positions

$$\text{Reading} \pm \frac{f}{400}\left[0.00001 + 0.005(\text{quad ratio})\right]$$

Angular Position

$$\text{Reading} \pm \frac{f}{400}\left[0.00001 + 0.0001(\Theta)\right]$$

Quadrature
Rectangular Positions

$$\text{Reading} \pm \left[\frac{f}{400}(0.0005) + 0.001(\text{quad ratio})\right]$$

Angular Position

$$\text{Reading} \pm \left[\frac{f}{400}(0.03) + 0.005\,(\Theta)\right]$$

Θ = measured angle in degrees
f = signal frequency in cps

RANGE:

In-phase Ratios:	0.000000 to 1.11111
Quadrature Ratios:	
Rectangular High	0.00000 to 0.50000
Rectangular Low	0.00000 to 0.10000
10° Angle	0.00000° to 10.000°

REFERENCE VOLTAGE:
2 Ranges:
5 - 25 V RMS
25 - 125 V RMS

SENSITIVITY:
Null Detector 10 uv

PROBE INPUT IMPEDANCE:

At null:	20,000 megohms + 0.01 pf
Off null:	1 megohm minimum + 100 pf

INPUT POWER
115/230 VAC, 50-400 cps, 70 VA

SIZE:

Cabinet:	19-1/2"W x 16-1/2"H x 13"D
Rack:	19W" x 14"H x 12"D

SECTION II
THEORY OF OPERATION

2-1. GENERAL.

2-2. This section includes a block diagram (see figure 2-1) and a detailed theory of operation. For a comprehensive general theory, refer to the Model CRB-8 Operation Book.

2-3. INTERNAL VOLTAGE GENERATION. (See figure 6-1.)

2-4. The reference voltage is applied across the in-phase ratio transformer and a portion of the reference voltage is applied through the quadrature generator to the quadrature ratio transformer. The selected outputs of the two ratio transformers are combined in the summing transformers T802 and T806 and applied to the chassis of the isolation amplifier.

2-5. IN-PHASE RATIO TRANSFORMER. (See figure 2-2.) The ratiotransformer consists of six transformer windings and six rotary switches. A portion of the input voltage is selected from each winding and these portions are added together to form the output voltage.

2-6. The full input voltage is applied across the X.1 winding which is tapped to provide ten precise voltage divisions. The lower wiper arm of switch S816 selects the X.1 portion of the input voltage. The lower wiper arm of switch S817 selects an X.01 portion of the input voltage which is added to the X.1 portion. The addition and referencing process continues through the six windings.

2-7. The six windings are included in two transformers with the first three on one common core and the last three on a second. The switches include resistors R823 through R828 which provide transient suppression during switching.

2-8. UNITY CALIBRATION CIRCUIT. (See figure 2-3.) Because of the wide frequency range, the gain and phase characteristics of the circuitry can vary. The unity calibration circuit includes components to compensate for these variations.

2-9. IN-PHASE switch S822 and potentiometer R803 compensate for any gain variations. Switch S822 is the coarse control and selects a set of taps on transformer

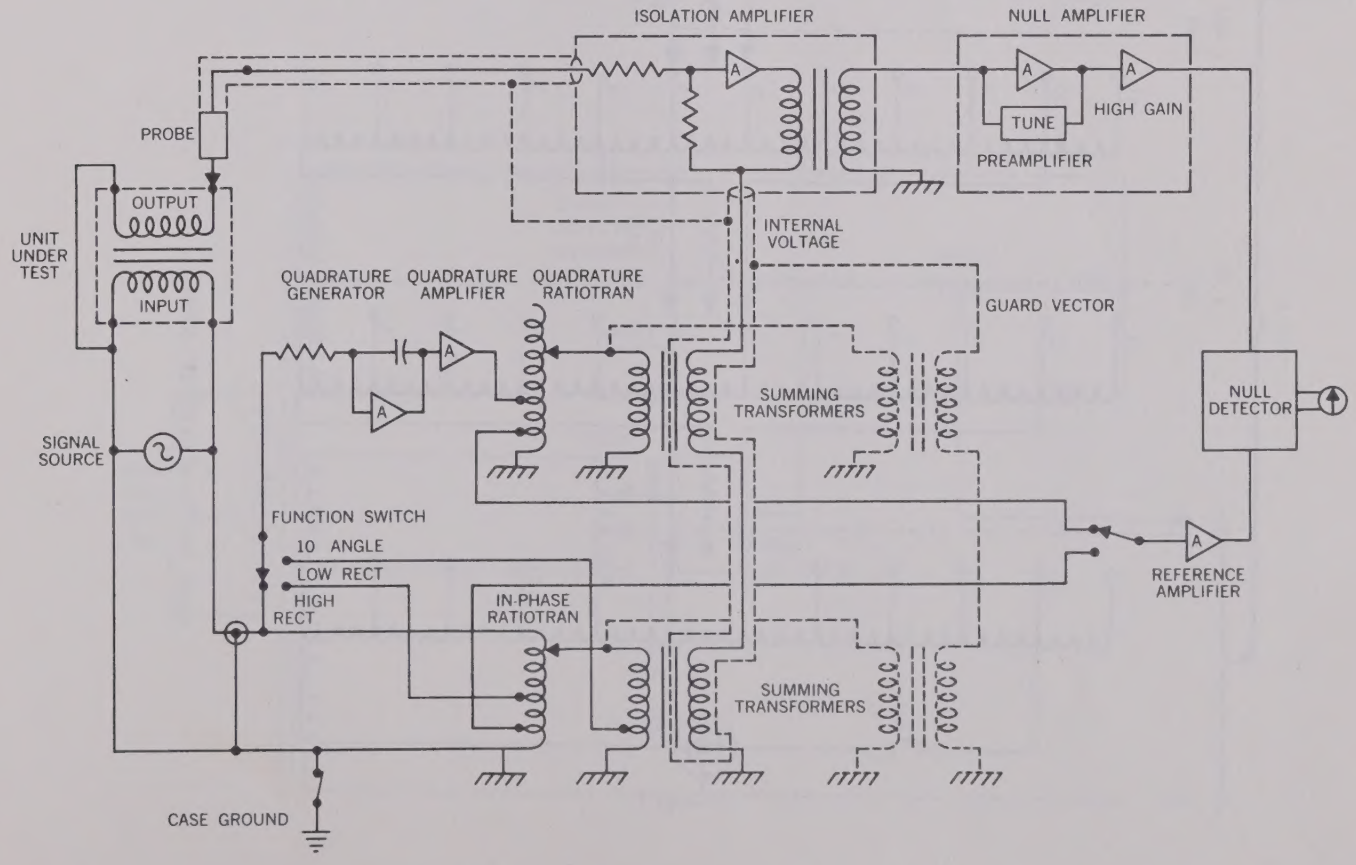


Figure 2-1. Block Diagram

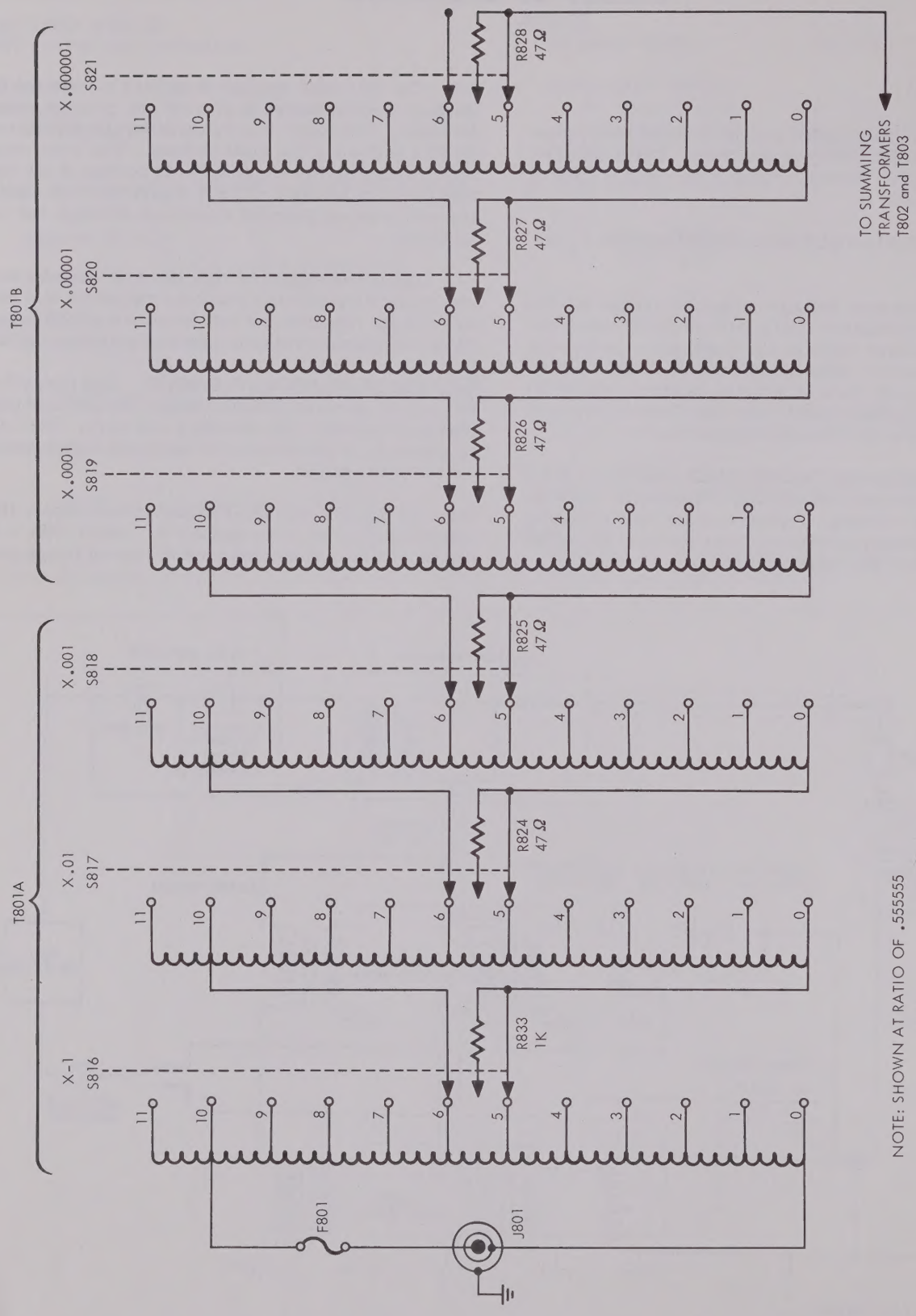


Figure 2-2. Ratio Transformer Equivalent Schematic

T804. Potentiometer R803 is the vernier control and sets the output of the summing transformer as required for exact readings of the in-phase ratio transformer.

2-10. QUADRATURE switch S815 and potentiometer R802 compensate for any phase variations. Resistor R801 and the capacitor value selected by switch S809 form a 90° phase shift network. The 90° voltage is applied to one side of potentiometer R802 and a 0° voltage is applied to the other. Thus a variable amount of quadrature voltage is available to either add to or subtract from the in-phase voltage from potentiometer R803.

2-11. QUADRATURE GENERATOR. (See figure 6-6.) The quadrature voltage is generated by amplifier V501 and V502 connected as an integrator. Since the open loop gain is very large compared to the closed loop gain, the output sine wave is an accurate integral of the input sine wave, or the input sine wave shifted by 90°. The value of the feed back capacitor varies over the frequency range and therefore FREQUENCY switch S809 selects the required capacitor C506 through C515.

2-12. Since the output of the generator varies with frequency, QUADRATURE LEVEL switch S808 and vernier potentiometer R503 adjust the quadrature output voltage. Potentiometer R546, in series with potentiometer R503, is a centering device. The potentiometer assures continuous gain control throughout the frequency range.

2-13. Potentiometers R547 through R556 are used to correct any small error angle in the quadrature voltage. If the quadrature voltage is not exactly 90°, it contains a small in-phase portion. This voltage is combined with voltage from the in-phase ratio transformer and causes an error in the in-phase ratio reading. The potentiometer supply a small amount of in-phase voltage (plus or minus) to cancel any in-phase portion of the quadrature voltage.

2-14. The quadrature signal is amplified to the required level by the amplifiers V503, V504, and V505. The amplifier is stabilized by both positive and negative feedback. Capacity compensation in the feedback network corrects for any phase shift through the amplifier. Direct coupling between stages provides dc stability.

2-15. QUADRATURE RATIO TRANSFORMER. The quadrature ratio transformer is similar to the in-phase ratio transformer except that only five decades are used and the input voltage is injected at different points for the different modes of operation.

2-16. NULL DETECTION.

2-17. The internal voltage is applied to the chassis of the isolation amplifier. Any difference between the signal input and the internal voltage is amplified by the isolation amplifier and the null amplifier and delivered to the null detector. The null detector is used to detect in-phase or quadrature nulls, dependent on the position of IN-PHASE/QUADRATURE switch S805. The reference voltage for the null detector is supplied by taps on either the in-phase or quadrature ratio transformer and delivered to the detector through the reference amplifier.

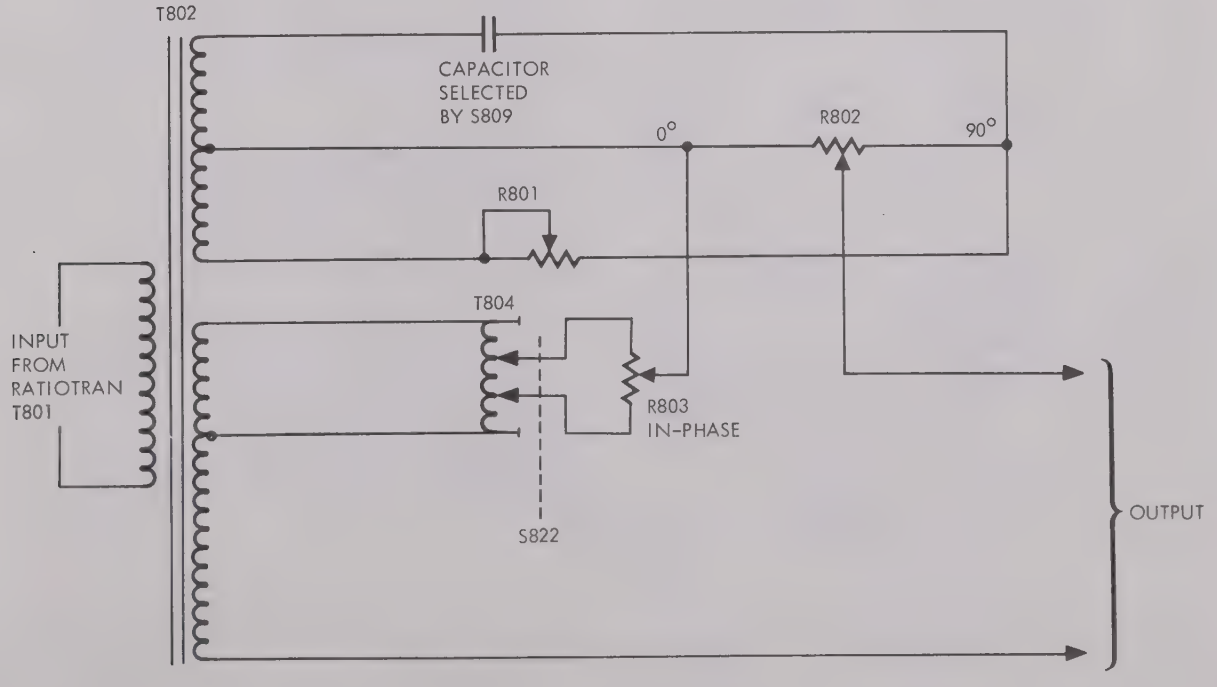


Figure 2-3. Unity Calibration Circuit

2-18. ISOLATION AMPLIFIER. (See figure 6-3.) The isolation amplifier is completely floating and is supplied with power through a separate, ungrounded 12 vdc supply. The input signal is the difference between the signal input voltage and the internal voltage applied to the chassis. Large, off-null signals are limited by back-biased diodes CR201 and CR202. Thermistor RT201 compensates for bias shift due to temperature variation. Transistors Q201 and Q202 are connected as a boot-strap amplifier to increase input impedance. The output of the amplifier is fed to the null amplifier through transformer T201.

2-19. Connector J201 provides a means for measuring the noise and harmonic content of the input signal. The bridge nulls only to the fundamental component of the input signal. At null, any signal at the connector is therefore noise and harmonics. Since the gain characteristics of the amplifier can vary, the K factor noted in the operation book must be applied to any measurements made at the connector.

2-20. TUNED AMPLIFIER. (See figure 6-4.) The tuned preamplifier portion of the null amplifier reduces the noise and harmonic content of the null signal. A feedback circuit effectively cancels all but the fundamental component.

2-21. Transistors Q301, Q302, and Q303 operate as an impedance-matching preamplifier. Diodes CR301 and CR302 limit large off-null signals. The output of the amplifier is delivered to the tuned feedback circuit Q304 and Q305 and to the null amplifier.

2-22. The tuned feedback circuit as shown in figure 2-4 consists of two RC networks. One of the networks can be tuned to produce a voltage shifted in phase by 90° and the second produces a 270° voltage. Since the two voltages are 180° out of phase with each other, they are effectively cancelling voltages. The circuits are coarse tuned to the fundamental signal by phasing switch S809 which selects resistors and fine tuned by potentiometer R336. Therefore the output feedback signal is minimum at the fundamental input. Noise and harmonics produce unbalanced outputs from the RC networks and therefore maximum feedback signals.

2-23. Potentiometer R312 in amplifier Q304 is the sensitivity control for the null amplifier. The potentiometer can be adjusted to produce an unbalanced input to the RC networks and therefore an unbalanced output signal. Effectively the potentiometer sets the output level of the preamplifier portion by varying the amount of feedback.

2-24. NULL AMPLIFIER. (See figure 6-5.) The null amplifier consists of three sets of amplifier stages and the phase sensitive null detector. The first amplifier stage Q401, Q402, and Q403 is typical of the three sets. Feedback through R409 is used to stabilize the amplifier. A second feedback path which includes diodes CR401 and CR402 is used to shape and limit the output signal. The back-to-back diodes provide a square wave output when the input signal is sufficiently large.

2-25. NULL DETECTOR. (See figure 2-5.) The null detector operates as an ac bridge which detects either the in-phase or quadrature component of the signal. With the IN-PHASE/QUADRATURE switch S805 in the

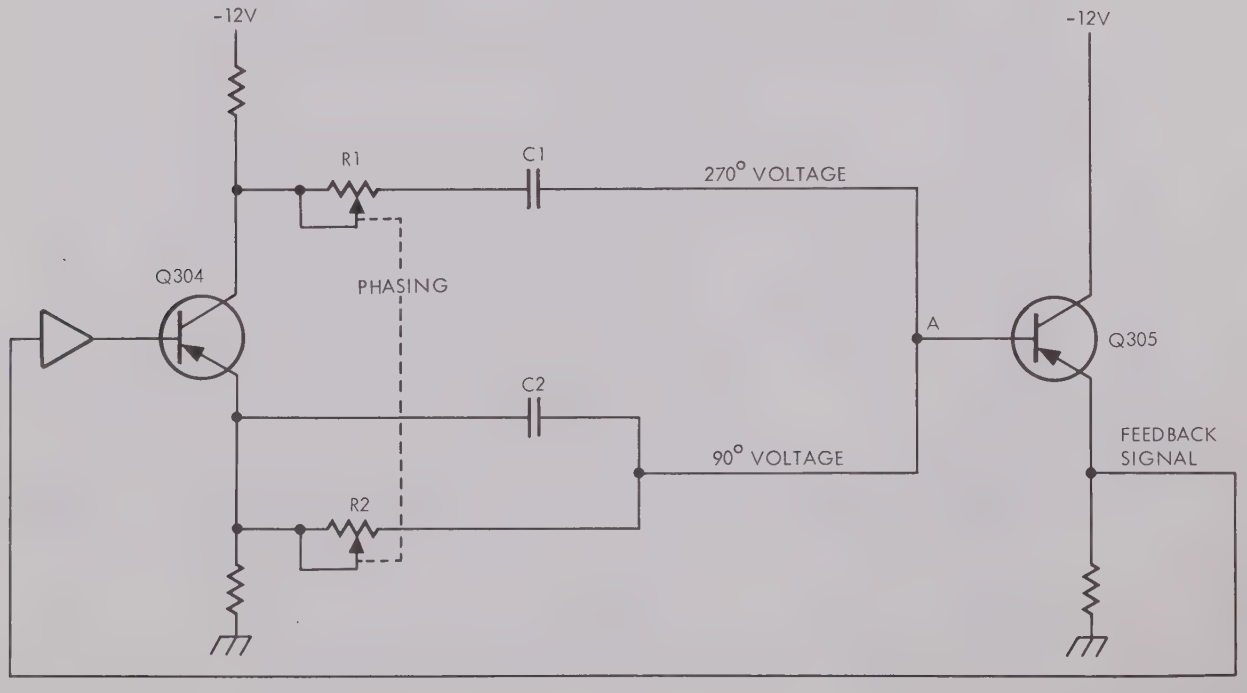


Figure 2-4. Simplified Feedback Circuit

IN-PHASE position the detector reacts to the IN-PHASE component of the signal. As the in-phase component decreases, the voltage differential between points A and C decreases. Therefore, meter M801 indicates a null when the signal into the bridge contains no in-phase component.

2-26. The bridge is sensitive to phase differences. When the voltage across points A and C of the bridge is exactly 90° out of phase with the voltage across points B and D, the voltage differential between points A and C is minimum. Therefore, when the signal received from the null amplifier is exactly 90° out of phase with the in-phase reference voltage, meter M801 indicates a null. This null point is reached when the signal consists entirely of a quadrature voltage.

2-27. Assuming the input signal to the bridge to be 45° out of phase with the reference voltage and the internal voltage to be zero, the null detector will detect an in-phase component. As the in-phase ratio transformer T801 is adjusted to apply an in-phase component to the chassis of the isolation amplifier, the resultant signal contains diminishing amounts of in-phase component. When the in-phase component of the internal voltage exactly equals the in-phase component of the input signal, the resultant signal contains only a quadrature component. The resultant signal, amplified by the null amplifier, is applied to points A and C of the null detector. Since this signal is exactly 90° out of phase with the in-phase reference voltage, meter M801 indicates a null. The amount of in-phase voltage required to achieve a null is indicated by the setting of the in-phase ratio transformer T801.

2-28. Meter M801 is a center null meter, connected to deflect to the left of center when an in-phase voltage is present. If, instead, the meter deflects to the right this indicates that the in-phase reference voltage should be inverted by turning the 0° -180° switch to the opposite position.

2-29. When the IN-PHASE/QUADRATURE switch is turned to the QUADRATURE position, the null detector reacts to the quadrature components as previously described for the in-phase components. The push-pull reference voltage is supplied from the quadrature generator.

2-30. REFERENCE AMPLIFIER. (See figure 6-7.) The reference amplifier consists of transistors Q601, Q602, and Q603 connected as a feedback controlled amplifier. The amplifier receives a fixed portion of the reference voltage through switch S805. Range switch S803 and the REFERENCE LEVEL controls provide a relatively fixed reference voltage output regardless of changes in input level.

2-31. Switch S803 controls output level by selecting one of two input resistors R601 or R602. Switch S802 is the coarse level control and selects the amount of feedback. Potentiometer R613 is the vernier level control. Potentiometer R626 is the centering control for the vernier potentiometer. Capacitors C602 and C606 compensate for phase shift through the amplifier.

2-32. LEVEL COMPARISON. (See figure 6-8.)

2-33. The level comparison circuit is essentially a voltmeter circuit. Diodes CR701 and CR702 and the associated components form a peak-to-peak rectifier circuit. These components apply a dc equivalent of the reference amplifier output to one side of meter M801. Zener diode CR703 and the associated resistors apply a comparison dc signal to the other side of the meter. The comparison signal is adjusted by potentiometer R705. Diodes CR704 and CR705 and capacitor C703 are connected across the meter for protection and rectification. Resistor R707 is part of the IN-PHASE/QUADRATURE indicator system.

2-34. PHASING SIGNAL CIRCUIT. (See figure 6-1.)

2-35. The phasing signal, used to tune the null amplifier, must be small to avoid overdriving the amplifier and yet large enough to provide a detectable output for any phase shift. Resistors R804 through R817 provide a variable attenuation circuit for the phasing signal. Part of the attenuation is selected by range switch S803 and the remainder by reference level switch S802.

2-36. POWER SUPPLY. (See figure 6-2.)

2-37. The power supply consists of five separate power supplies:

a. A 12 volt, ungrounded supply for the isolation amplifier.

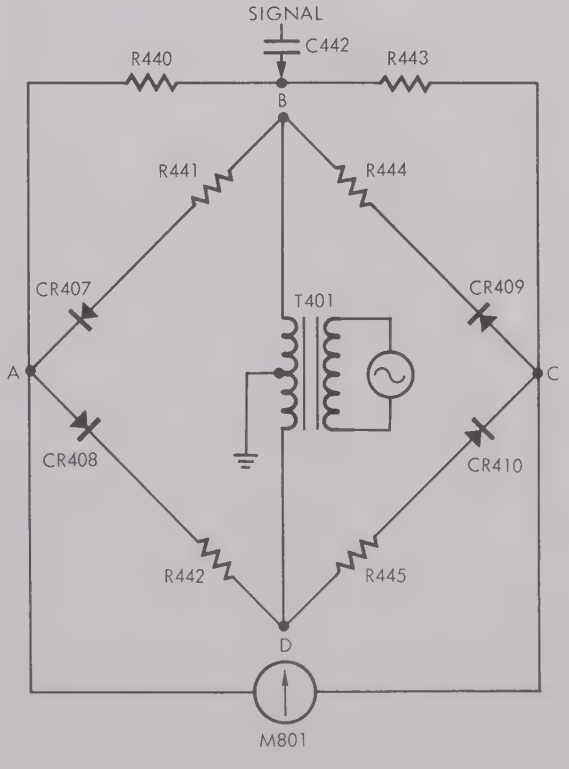


Figure 2-5. Null Detector

b. A - 6.8, -12, and -35 vdc supply.

c. A + and -200 vdc supply for the quadrature generator.

d. A 6.3 vac supply, referenced to -200 vdc.

e. A second 6.3 vac supply.

2-38. INPUT CIRCUIT. The input circuit includes the power switch S823, fuse F801, and the power conversion switch S101. With switch S101 in the 230 position, the input power is applied across the full primaries of transformers T101 and T102. With the switch in the 115 position, power is applied at a 1/2 point tap of the primaries.

2-39. ISOLATED 12 VOLT SUPPLY. Transformer T101 provides the stepped-down voltage for the isolated 12 volt supply. The voltage is rectified by rectifier bridge A101, filtered in a capacitor input circuit, and regulated by Zerner diode CR101.

2-40. -6.8, -12, AND -35 VDC SUPPLY. Three voltages are developed by a power supply consisting of one secondary of T102, bridge rectifier A102, a capacitor input filter, and regulation elements. Transistor Q101 is the series element for the -35 vdc regulation and transistor Q102 furnishes dc error amplification. Transistor Q102 is referenced by Zener diode CR102. The 12 volt supply is regulated by Zener diode CR103 and the -6.8 volt supply is regulated by Zener diode CR104.

2-41. 200 VOLT SUPPLIES. The + and -200 vdc supplies are developed in a power supply consisting of one secondary of transformer T102 and bridge rectifier A103. Each of the voltages is filtered by a capacitor input circuit and each is regulated by a separate Zener diode.

SECTION III
MAINTENANCE

3-1. GENERAL.

3-2. With the exception of cleaning switch contacts, no maintenance on a regularly scheduled basis is required. Moving parts are lubricated at the factory and should require no further lubrication.

3-3. SWITCH CONTACTS.

3-4. Once every three to six months, clean switch contacts with a good grade of solvent such as alcohol. Relubricate contacts with a layer of vaseline.

3-5. DEGAUSSING.

3-6. If dc voltage is accidentally applied to the input terminals, degauss the unit as follows:

a. Connect a 1K resistor in series with the center conductor of the REF jack.

b. By means of a variac or other suitable voltage control, apply a 60 cps signal between the open end of the 1K resistor and the outer conductor of the REF jack.

c. Starting with the voltage control at zero, increase voltage to 40 vrms.

d. Slowly decrease the voltage to zero. The period of time to reduce the voltage from 40 vrms to zero should be between 10 and 15 seconds.

3-7. REPAIRS.

3-8. If any repairs are made on the unit or if any parts are replaced, check the accuracy of the unit as outlined in Section IV. If any transformer problems are encountered, it is recommended that the unit be returned to the factory for overhaul and recalibration.

SECTION IV
CALIBRATION

4-1. GENERAL.

4-2. Check the fundamental accuracy of the instrument every 90 days as outlined in paragraphs 4-5 through 4-8. If the instrument is out of calibration, proceed to the adjustment procedures outlined in paragraphs 4-9 and subsequent. The tests and adjustments should only be performed by a qualified instrument laboratory. All tests and adjustments should be performed after a thirty minute warm-up.

4-3. To perform the calibration tests outlined in paragraphs 4-5 through 4-9, the following test equipment (or equivalent) is required:

a. Variable Phase Standard - Gertsch Model VPS-1.

b. AC Ratio Standard - Gertsch Model 1011.

4-4. To perform the adjustments, the following additional test equipment (or equivalent) is required:

a. Oscillator - Hewlett Packard Model 200CD.

b. Oscilloscope.

c. Quadrature Standard - Gertsch Model QS-1 equipped with the following frequencies:
   (1) 400
   (2) 520
   (3) 680
   (4) 865
   (5) 1150
   (6) 1500
   (7) 2000
   (8) 2600
   (9) 3400
   (10) 4500

4-5. CALIBRATION TEST.

4-6. HIGH RECTANGLE MODE.

a. Interconnect equipment as shown in figure 4-1.

b. Adjust variable phase standard to produce a 50 vrms, 400 cps reference voltage.

c. Set AC ratio standard to a 1.0000000 ratio.

d. Adjust ratio bridge to the reference input.

e. Set IN-PHASE (Cos Θ) controls of the variable phase standard to .999999.

f. Connect probe to the vector jack.

g. Turn FUNCTION switch to the IN-PHASE position.

h. Adjust AC ratio standard as required to obtain a null on the meter.

i. Turn FUNCTION switch to the HIGH RECT position.

j. Set variable phase standard to the values specified in table 2 with the quadrant switch in the first quadrant position.

k. Null the ratio bridge for each setting of the variable phase stnadard.

l. Check that readouts are within the limits set in table 2.

m. Repeat test procedure with the variable phase quadrant switch in the second, third, and fourth

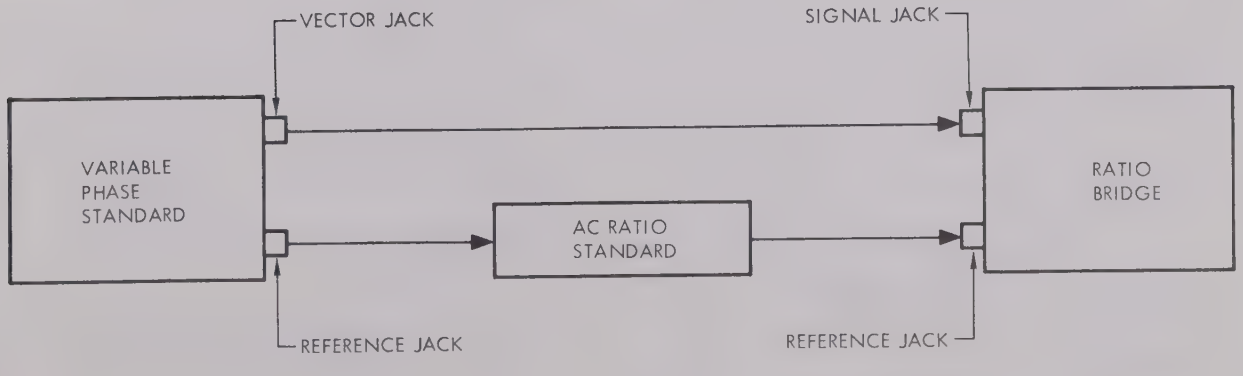


Figure 4-1. Calibration Test Setup

TABLE 2. CALIBRATION TEST TABLE (400 CPS)

STEP	VARIABLE PHASE STANDARD SETTINGS		RATIO BRIDGE READOUT LIMITS			
			IN-PHASE		QUADRATURE	
	IN-PHASE	QUADRATURE	MAX	MIN	MAX	MIN
1	.900000	.100000	.900510	.899490	.20080	.19920
2	.700000	.300000	.701510	.698490	.60140	.59860
3	.500000	.500000	.502510	.497490	1.00200	.99800
4	.300000	.400000	.302010	.297990	.80170	.79830
5	.100000	.200000	.101010	.098990	.40110	.39890

quadrant positions. Nulls shall be obtained with the ratio bridge switches in the following positions.

QUADRANT	0° - 180°	90° - 270°
FIRST	0°	90°
SECOND	180°	90°
THIRD	180°	270°
FOURTH	0°	90°

n. Repeat test procedure at each applicable operating frequency. Determine readout limits from the following formulae:

IN-PHASE LIMITS

$$\text{Reading} \pm \frac{f}{400} .00001 + .005 \text{ (QUAD RATIO)}$$

QUADRATURE LIMITS

$$\text{Reading} \pm \frac{f}{400} (.0005) + .001 \text{ (QUAD RATIO)} \pm .001 \times \text{QUAD RATIO (calibration error of test equipment)}$$

4-7. LOW RECTANGLE MODE.

a. Interconnect and adjust equipment as outlined in paragraph 4-6.

b. Turn FUNCTION switch to the LOW RECT position.

c. Set variable phase standard controls as follows with the quadrant switch in the first quadrant position:

IN-PHASE - .900000
QUADRATURE - .100000

d. Null the ratio bridge.

e. The readouts shall be within the following limits:

IN-PHASE - - .899490 to .900510
QUADRATURE - .09930 to .10070

4-8. 10° ANGLE MODE.

a. Interconnect and adjust equipment as outlined in paragraph 4-6, steps a through h.

b. Turn FUNCTION switch to the 10° ANGLE position.

c. Set variable phase standard to the following values:

IN-PHASE (cos Θ) = .984808
QUADRATURE (SINE Θ) = .173648

d. Null the ratio bridge.

e. The quadrature controls shall indicate an angle of 10.000° ± .08 ± .05 (calibration error of test equipment).

4-9. ADJUSTMENT PROCEDURES.

4-10. POWER SUPPLY.

a. Remove four screws which attach the power supply chassis.

b. Connect voltmeter between point T and point N of the power supply printed circuit board.

c, Turn power on.

d. Adjust potentiomter R106 as required to set voltage to -35 vdc.

4-11. UNITY ADJUSTMENT.

a. Turn power off.

b. Disconnect lead from wiper of IN-PHASE (unity cal) potentiometer and connect lead to ground.

c. Turn FUNCTION switch to REFERENCE LEVEL.

d. Apply 30 vrms at 400 cps to REFERENCE connector.

e. Connect oscilloscope across QUADRATURE (unity cal) potentiometer. Adjust oscilloscope to measure a 90° phase shift.

f. Adjust resistor R801 as required to obtain a 90° phase shift through the adjustment circuit.

g. Turn reference voltage off and reconnect lead to wiper of IN-PHASE (unity cal) potentiometer.

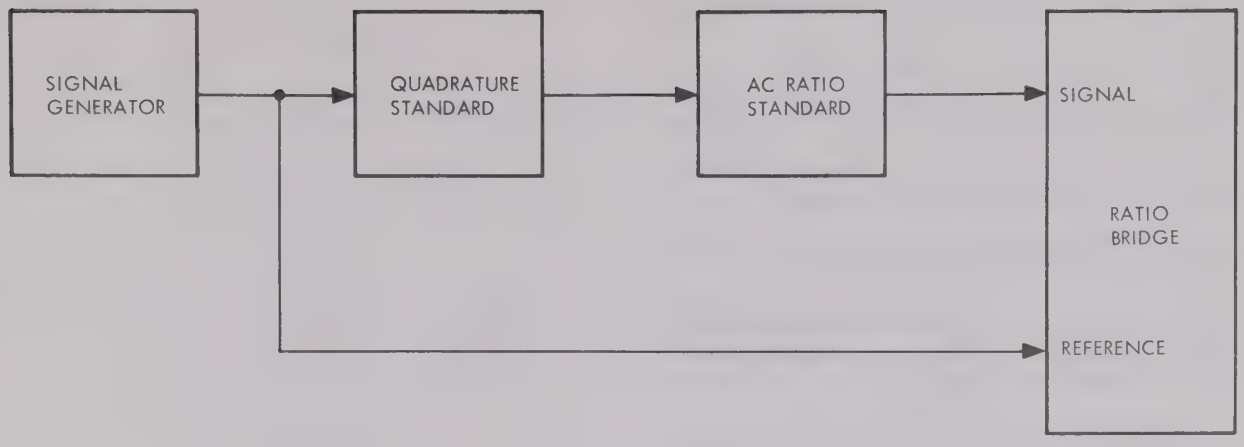


Figure 4-2. 90 Degree Adjustment

4-12. SENSITIVITY ADJUSTMENT.

a. Turn power on and allow a 5 minute warmup.

b. Connect a 24 vrms, 400 cps signal to the reference input.

c. Connect probe cable assembly between SIGNAL and PRE-USE CAL connector.

d. Turn FREQUENCY switch to 350 - 450.

e. Turn FUNCTION switch to REF LEVEL.

f. Turn RANGE switch to 24 - 125 VRMS.

g. Adjust REFERENCE LEVEL switch and vernier control as required to obtain a null on the meter.

h. Turn FUNCTION switch to QUAD LEVEL.

i. Adjust QUADRATURE LEVEL switch and vernier control as required to obtain a null on the meter.

j. Turn FUNCTION switch to PHASING.

k. Adjust PHASING switch and vernier control as required to obtain a null on the meter.

l. Turn FUNCTION switch to IN-PHASE.

m. Adjust IN-PHASE (unity cal) switch and vernier control as required to obtain a null on the meter.

n. Turn FUNCTION switch to QUADRATURE.

o. Adjust QUADRATURE (unity cal) switch and vernier control as required to obtain a null on the meter.

p. Turn FUNCTION switch to HIGH RECT.

q. Adjust IN-PHASE and QUADRATURE ratio controls as required to obtain a null on the meter.

r. Increase IN-PHASE ratio by .00010 from null setting.

s. Adjust resistor R312 as required to obtain a meter deflection of 4 to 5 divisions from center null.

4-13. REFERENCE LEVEL ADJUSTMENT.

a. Turn power on and allow a 5 minute warmup.

b. Connect a 25 vrms, 5KC signal to the reference input.

c. Turn FUNCTION switch to REF LEVEL.

d. Turn RANGE switch to 25 - 125 VRMS.

e. Set REFERENCE LEVEL switch and vernier control to the minimum position (ccw).

f. Connect oscilloscope to points B and chassis of the reference amplifier and adjust oscilloscope to measure phase shift.

g. Adjust capacitor C606 (across R611) as required to obtain minimum phase shift through the amplifier.

h. Reduce reference input signal to 5 vrms.

i. Turn RANGE switch to the 5 to 25 vrms position.

j. Adjust capacitor C602 (across R601) as required to obtain minimum phase shift through amplifier.

k. Set reference input signal to 4.6 vrms at 400 cps.

l. Adjust REFERENCE LEVEL vernier control and check that null can be obtained. If null cannot be obtained, set vernier control to minimum and adjust resistor R626 as required to obtain a null.

m. Increase reference input signal to 26 vrms.

n. Set REFERENCE LEVEL switch to the maximum position (cw).

o. Adjust REFERENCE LEVEL vernier control and check that null can be obtained. If null cannot be obtained, set vernier control to minimum and adjust resistor R704 as required to obtain a null.

p. Since considerable interaction can exist among the various controls, repeat steps b through o.

4-14. QUADRATURE ADJUSTMENT.

a. Turn FREQUENCY switch to 350 - 450.

b. Set reference input to 5 vrms at 350 cps.

c. Turn FUNCTION switch to REF LEVEL.

d. Turn RANGE switch to 5 - 25 vrms.

e. Adjust REFERENCE LEVEL switch and vernier control as required to obtain a null on the meter.

f. Turn FUNCTION switch to QUAD LEVEL.

g. Set resistor R546 to approximately mid position.

h. Set QUADRATURE LEVEL switch and vernier control to the minimum position (ccw).

i. Adjust reference input frequency until the meter indicates a null.

j. Turn FUNCTION switch to REF LEVEL and check that meter indicates a null. Reset REFERENCE LEVEL control if required.

k. Return FUNCTION switch to QUAD LEVEL and check that meter indicates a null. Reset frequency as required.

l. The null frequency shall be at least 5 cps below the low frequency of the frequency range. Record null frequency.

m. Turn FUNCTION switch to PHASING.

n. Check that null may be obtained using the PHASING switch and vernier control.

o. Turn FUNCTION switch to QUAD LEVEL.

p. set QUADRATURE LEVEL switch and vernier to the maximum position (cw).

q. Adjust reference input frequency until the meter indicates a null.

r. Repeat steps j and k.

s. The null frequency shall be at least 5 cps above the high frequency range. Record null frequency.

t. Repeat steps m and n.

u. Repeat steps h through p for each range (see table 3).

v. Adjust resistor R546 as required to obtain the required 5 cps overlap at each end of each range and to obtain the best centering for all ranges.

4-15. LEVEL TESTS.

a. Set reference input to 5 vrms at 400 cps.

b. Turn FUNCTION switch to the REF LEVEL position.

c. Adjust REFERENCE LEVEL switch and vernier control as required to obtain a null on the meter.

d. Turn FUNCTION switch to the QUAD LEVEL position.

e. Adjust QUADRATURE LEVEL switch and vernier control as required to obtain a null on the meter.

TABLE 3. FREQUENCY RANGES

	FREQUENCY RANGE
1	350 450
2	450 585
3	585 770
4	770 1000
5	1000 1300
6	1300 1715
7	1715 2250
8	2250 2950
9	2950 3875
10	3875 5100

f. Repeat steps a through e at every 2 vrms increment between 5 and 25 vrms. Check that a null can be obtained at each switch position.

4-16. 90 DEGREE ADJUSTMENT.

a. Interconnect equipment as shown in figure 4-2.

b. Set signal generator to produce 25 vrms at 400 cps.

c. Adjust ratio bridge to the reference input.

d. Adjust quadrature standard to produce 90°.

e. Turn FUNCTION switch to LOW RECT.

f. Set QUADRATURE ratio controls to .10000 and IN-PHASE ratio controls to .000000.

g. Turn IN-PHASE - QUADRATURE switch to QUADRATURE.

h. Null out bridge by adjusting AC ratio standard.

i. Turn IN-PHASE - QUADRATURE switch to IN-PHASE and null out bridge using the IN-PHASE ratio controls.

j. Check that the IN-PHASE controls indicate a ratio of .000000 ± .000003. If required, adjust resistor R547 to obtain an in-phase readout within tolerance. (Resistors are identified on the top dust cover.)

k. Turn FUNCTION switch to HIGH RECT.

l. Set QUADRATURE ratio controls to .20000.

m. Repeat steps g through j.

n. Repeat procedure at remaining center frequencies.

SECTION V
PARTS LIST

MAIN CHASSIS COMPONENTS

REF DESIG	ITEM	PART NO.	MANUFACTURER
A801	Isolation Amplifier (See figure 5-4.)		
A802	Tuned Amplifier (See figure 5-5.)		
A803	Capacitor Assy, tuned amplifier (See figure 5-6.)		
A804	Capacitor Assy, tuned amplifier (See figure 5-7.)		
A805	Null Amplifier (See figure 5-8.)		
A806	Null Amplifier and Phase Detector (See figure 5-9.)		
A807	Resistor Assy, quadrature generator (See figure 5-10.)		
A808	Quadrature Generator (See figure 5-11.)		
A809	Capacitor Assy, quadrature generator (See figure 5-12.)		
A810	Adjustment Assy, unity cal (See figure 5-13.)		
A811	Level Comparison (See figure 5-14.)		
A812	Reference Amplifier (See figure 5-15.)		
A813	Power Supply (See figure 5-16.)		
*	Mounted on A810		
*C801	Capacitor, electrolytic, 18.1 uf, 15VDCW	BG12-18.1-15NP	MEC
*C802	Capacitor, electrolytic, 14.6 uf, 15VDCW	BG12-14.6-15NP	MEC
*C803	Capacitor, electrolytic, 11.1 uf, 15VDCW	BG12-11.1-15NP	MEC
*C804	Capacitor, electrolytic, 8.3 uf, 15 VDCW	BG12-8.3-15NP	MEC
*C805	Capacitor, electrolytic, 6.5 uf, 15VDCW	BG9-6.5-15NP	MEC
*C806	Capacitor, electrolytic, 5.0 uf, 15VDCW	BG12-5-15NP	MEC
*C807	Capacitor, electrolytic, 3.8 uf, 15VDCW	BG12-3.8-15VDC	MEC
*C808	Capacitor, electrolytic, 2.9 uf, 15VDCW	EG12-2.9-15NP	MEC
*C809	Capacitor, electrolytic, 2.2 uf, 15VDCW	BG12-2.2-15NP	MEC
*C810	Capacitor, electrolytic, 7.1 uf, 15VDCW	BG12-7.1-15NP	MEC
J801	Connector, Triax		
J802	Connector, Triax		

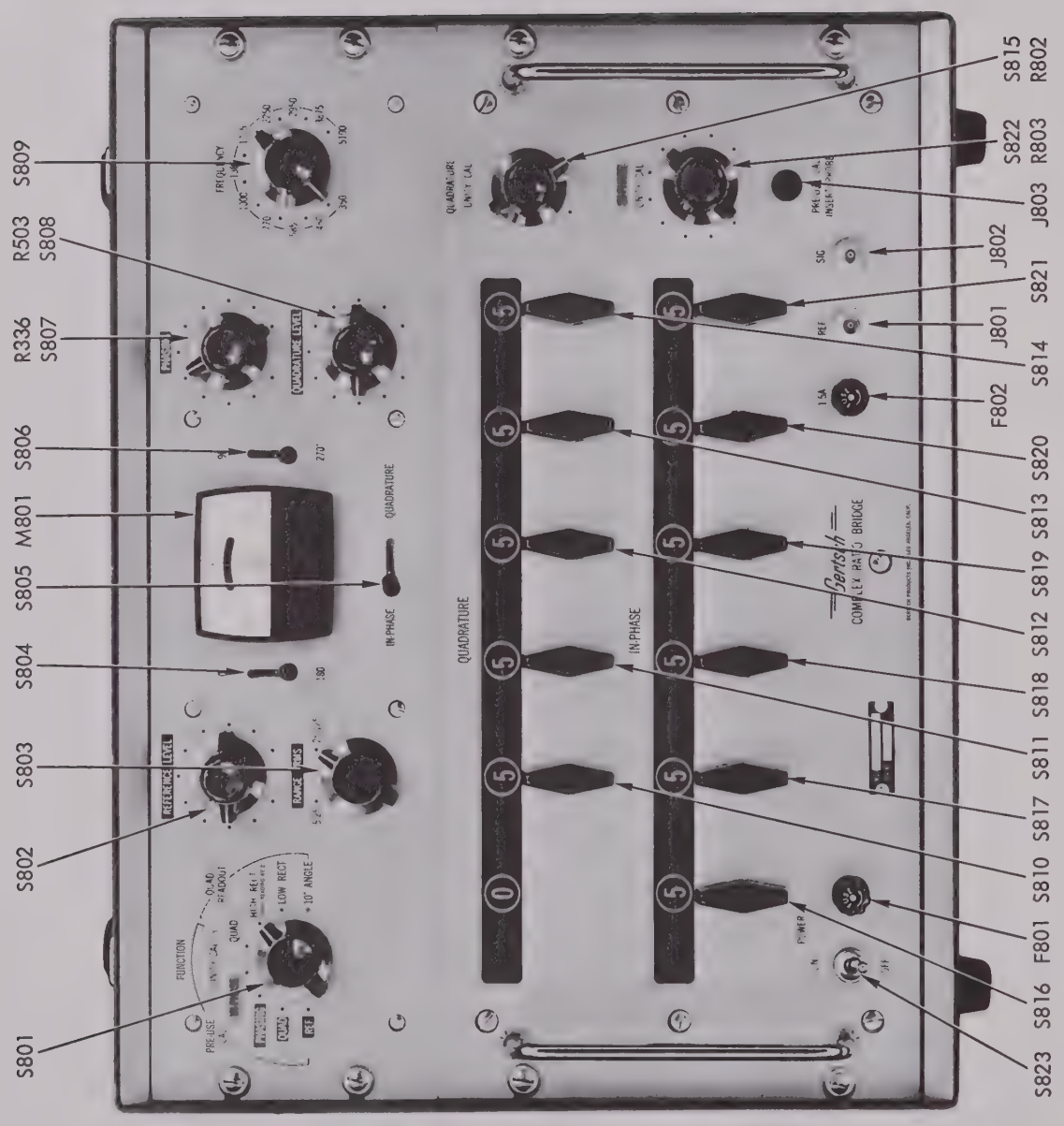


Figure 5-1. Front Panel View

REF DESIG	ITEM	PART NO.	MANUFACTURER
J803	Connector		
J804	Connector	MDR04-378	Deutsch
J805	Connector		
J806	Connector		
M801	Meter	AW422	Gertsch
P804	Connector	MDR04-37P	Deutsch
*R801	Resistor, Trimpot, 10 ohms	200P-1-100	Bourns
R802	Potentiometer, 25 ohms ±5%	A25L-5	Beckman
R803	Potentiometer, 2.9 ohms ±1%	Model 205	Borg
**	Mounted on S803		
**R804	Resistor, comp, 27 ohms ±10%, 1/2W		
**R805	Resistor, comp, 27 ohms ±10%, 1/2W		
**R806	Resistor, comp, 10 ohms ±10%, 1/2W		
R807 thru R817	Resistor, comp, 10 ohms ±10%, 1/4W (Mounted on S802)		
R818	Resistor, comp, 2.7K ±10%, 1/2W		
R819	Resistor, comp, 10 ohms ±10%, 1/2W		
R820	Resistor, comp, 10 ohms ±10%, 1/2W		
R821	Resistor, comp, 10 ohms ±10%, 1/2W		
R822	Resistor, comp, 10 ohms ±10%, 1/2W		
R823	Resistor, comp, 1K ±10%, 1/2W		
R824	Resistor, comp, 47 ohms ±10%, 1/2W		
R825	Resistor, comp, 47 ohms ±10%, 1/2W		
R826	Resistor, comp, 47 ohms ±10%, 1/2W		
R827	Resistor, comp, 47 ohms ±10%, 1/2W		
R828	Resistor, comp, 47 ohms ±10%, 1/2W		
R829	Resistor, comp, 1K ±10%, 1/2W		
R830	Resistor, comp, 47 ohms ±10%, 1/2W		
R831	Resistor, comp, 47 ohms ±10%, 1/2W		
R832	Resistor, comp, 47 ohms ±10%, 1/2W		
R833	Resistor, comp, 47 ohms ±10%, 1/2W		
S801	Switch, Rotary	SW-210	Gertsch

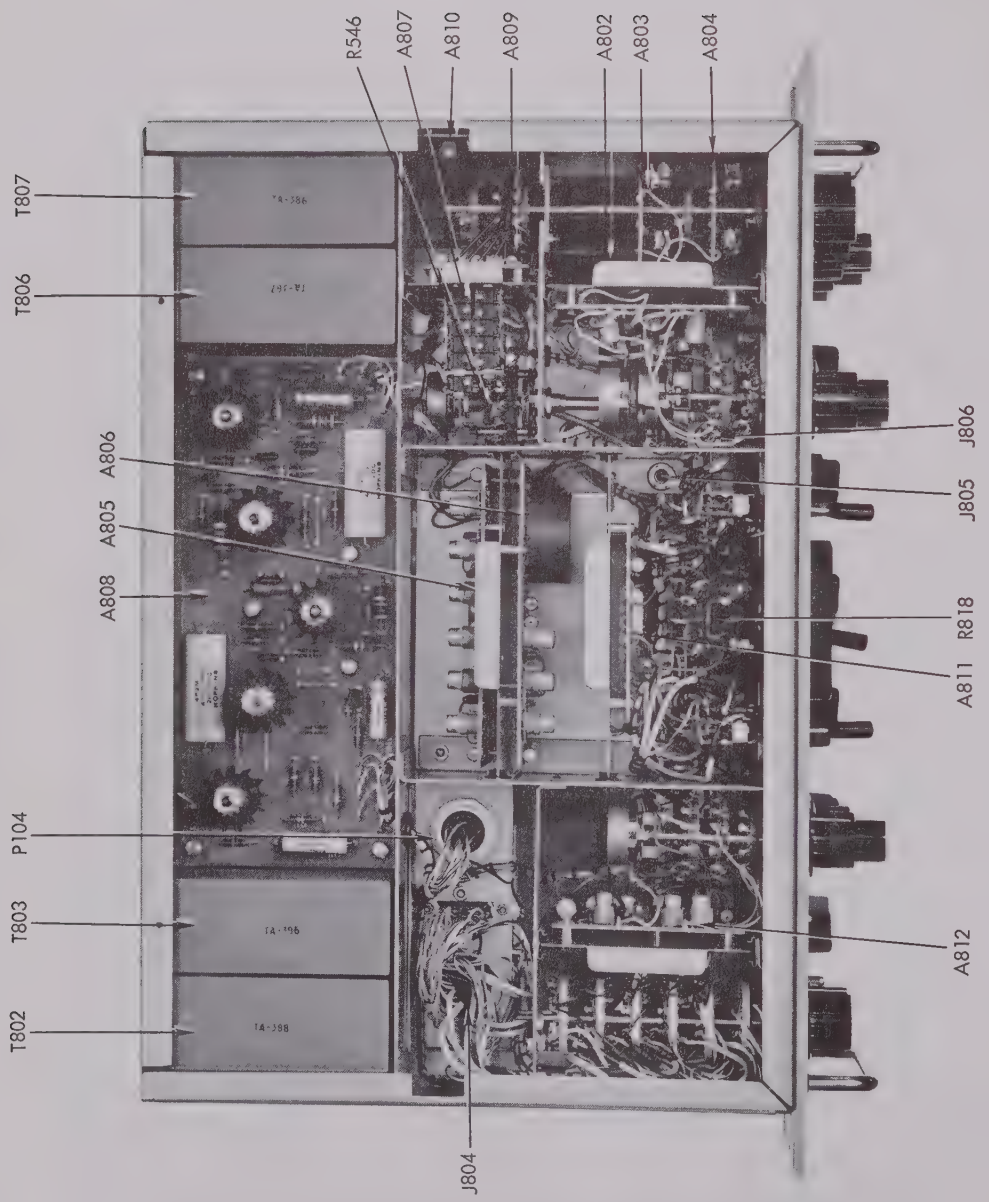


Figure 5-2. Top Chassis

REF DESIG	ITEM	PART NO.	MANUFACTURER
S802	Switch, Rotary	SW-212	Gertsch
S803	Switch, Lever	6242	Mallory
S804	Switch, Lever	6242	Mallory
S805	Switch, Lever	6242	Mallory
S806	Switch, Lever	6242	Mallory
S807	Switch, Rotary	SW-213	Gertsch
S808	Switch, Rotary	SW-214	Gertsch
S809	Switch, Rotary	SW-215	Gertsch
S810	Switch, Rotary	SW-217	Gertsch
S811	Switch, Rotary	SW-217	Gertsch
S812	Switch, Rotary	SW-217	Gertsch
S813	Switch, Rotary	SW-217	Gertsch
S814	Switch, Rotary	SW-217	Gertsch
S815	Switch, Rotary	SW-224	Gertsch
S816	Switch, Rotary	SW-217	Gertsch
S817	Switch, Rotary	SW-217	Gertsch
S818	Switch, Rotary	SW-217	Gertsch
S819	Switch, Rotary	SW-217	Gertsch
S820	Switch, Rotary	SW-217	Gertsch
S821	Switch, Rotary	SW-217	Gertsch
S822	Switch, Rotary	SW-216	Gertsch
S823	Switch, Toggle	2BL6273	Carling
T801A	Transformer, First three decades	TA-389	Gertsch
T801B	Transformer, Last three decades	TA-390	Gertsch
T802	Transformer	TA-388	Gertsch
T803	Transformer	TA-386	Gertsch
T804	Transformer	TA-229	Gertsch
T805	Transformer	TA-391	Gertsch
T806	Transformer	TA-387	Gertsch
T807	Transformer	TA-386	Gertsch
W802	Cable Assy, Probe	WA-47	Gertsch

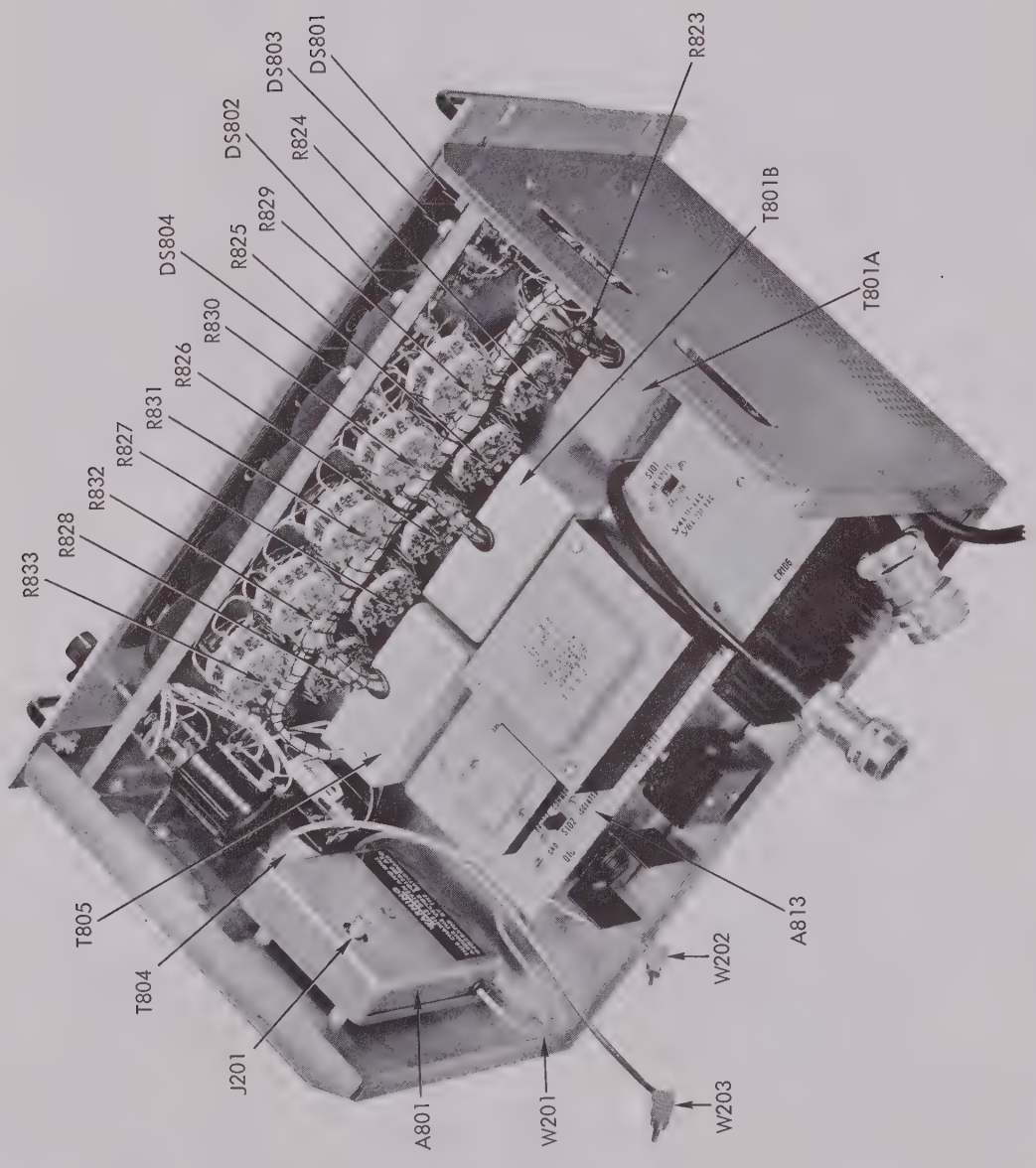


Figure 5-3. Lower Chassis (Sheet 1 of 2)

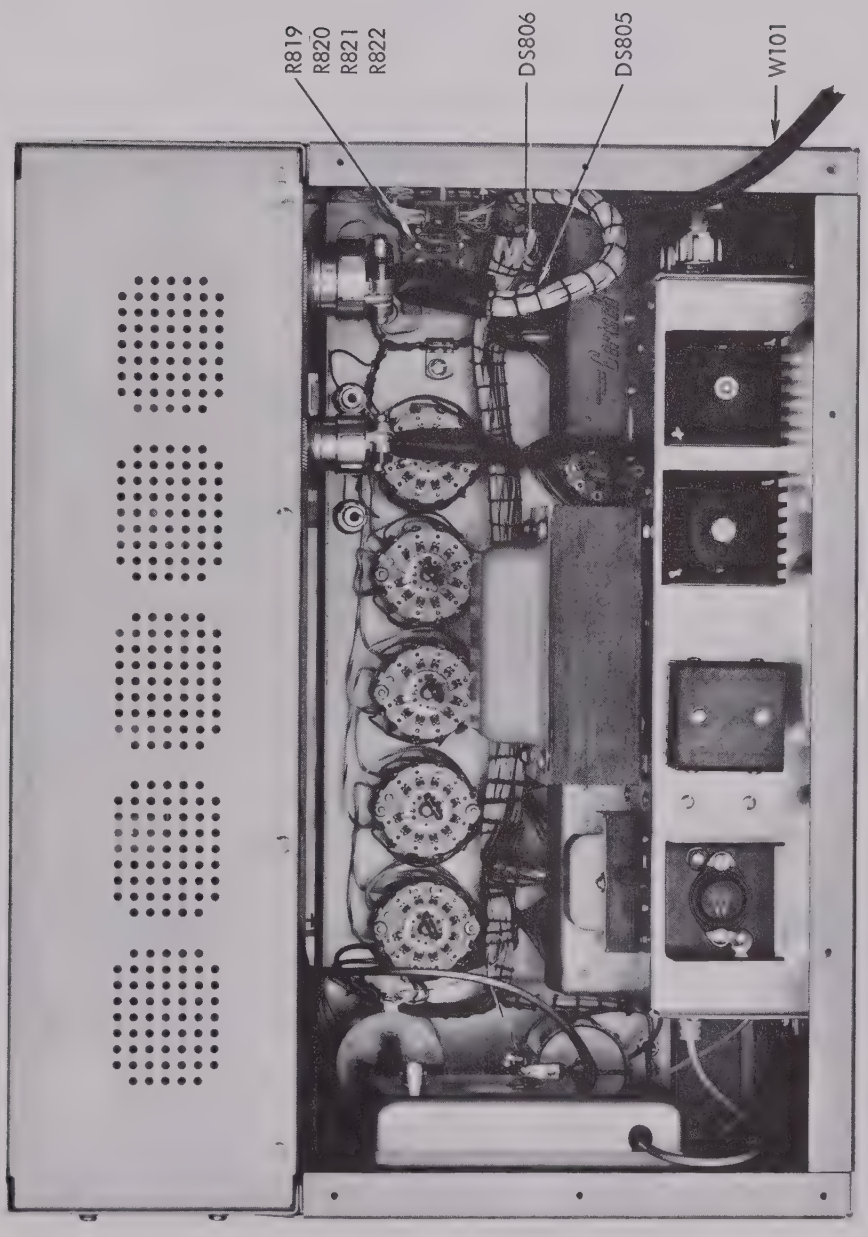


Figure 5-3. Lower Chassis (Sheet 2 of 2)

A801
ISOLATION AMPLIFIER

REF DESIG	ITEM	PART NO.	MANUFACTURER
C201	Capacitor, paper, 0.5 uf, 200 VDCW	P8292ZN12	Aerovox
C202	Capacitor, electrolytic, 20 uf, 15VDCW	TE1157	Sprague
C203	Capacitor, electrolytic, 20 uf, 15VDCW	TE1157	Sprague
C204	Capacitor, electrolytic, 20 uf, 15VDCW	TE1157	Sprague
CR201	Diode, silicon	1N457	Pac Semiconductor
CR202	Diode, silicon	1N457	Pac Semiconductor
Q201	Transistor, PNP	2N417	Tungsol
Q202	Transistor, PNP	2N417	Tungsol
R201	Resistor, wirewound, 1 meg ±1%, 1/4W	Type MDB	IRC
R202	Resistor, wirewound, 100K ±1%, 1/4W	Type MDB	IRC
R203	Resistor, comp, 33K ±10%, 1/4W		
R204	Resistor, wirewound, 221K ±1%, 1/4W	Type MDB	IRC
R205	Resistor, comp, 22K ±10%, 1/2W		
R206	Resistor, comp, 10K ±10%, 1/4W		
R207	Resistor, comp, 10K ±10%, 1/4W		
R208	Resistor, comp, 2.2K ± 10%, 1/4W		
RT201	Thermistor, 100K at 25°C	EP-43	Gertsch
T201	Transformer	TA-254	Gertsch
W201	Cable Assembly	WC-5-1	Gertsch
W202	Cable Assembly	WC-6	Gertsch
W203	Cable Assembly	WC-5-2	Gertsch

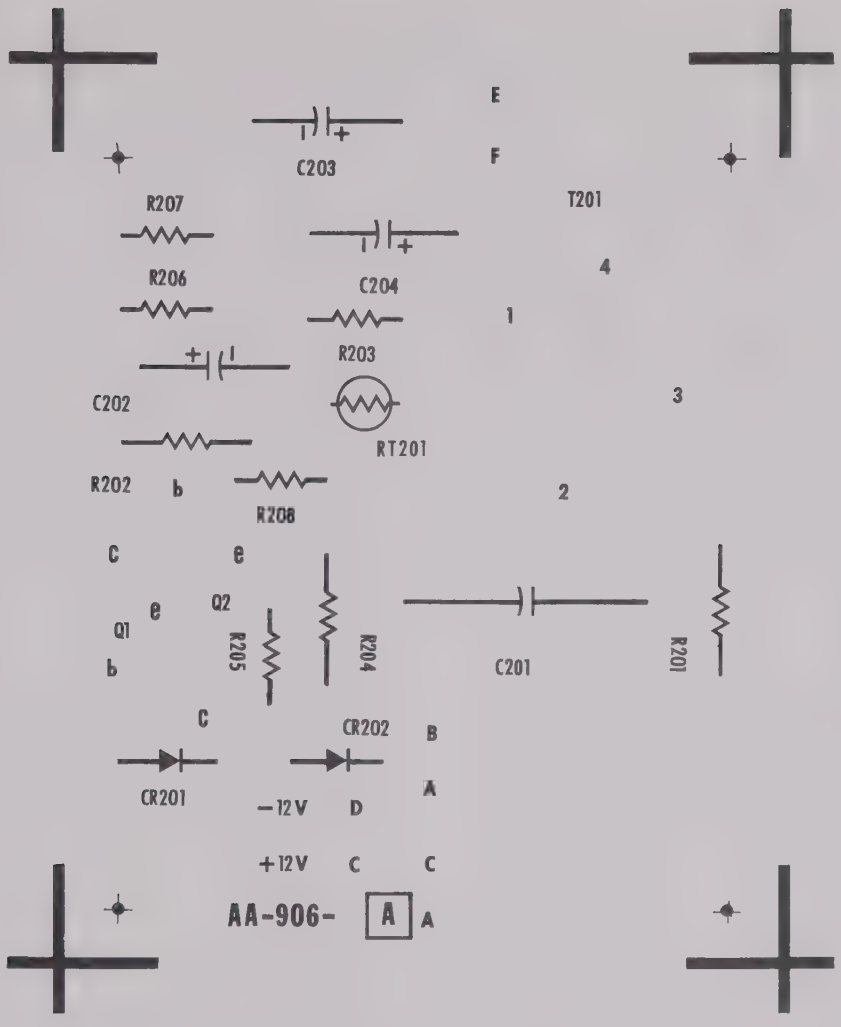


Figure 5-4. Isolation Amplifier

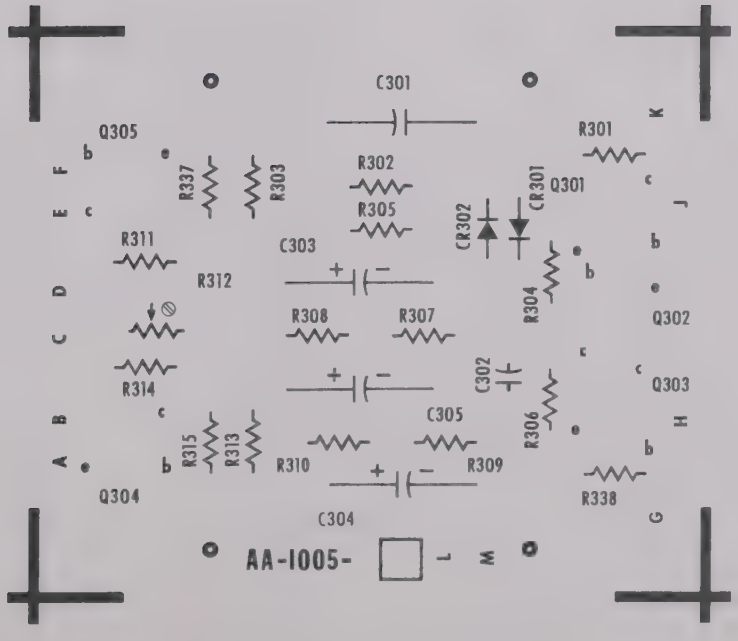


Figure 5-5. Tuned Amplifier

A802
TUNED AMPLIFIER

REF DESIG	ITEM	PART NO.	MANUFACTURER
C301	Capacitor, mylar, 0.47 uf, 50VDCW	WS4474	Westcap
C302	Capacitor, durmica, 240 pf, 200 VDCW	DM15E241J	Elmenco
C303	Capacitor, electrolytic, 50 uf, 15VDCW	P85AK-125015	MEC
C304	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-12515	MEC
C305	Capacitor, electrolytic, 50 uf, 15VDCW	P85AK-125015	MEC
*C306	Capacitor, durmica, 7500 pf ±1%, 100VDCW	DM19E752F	Elmenco
*C307	Capacitor, durmica, 6200 pf ±1%, 300VDCW	DM19E622F	Elmenco
*C308	Capacitor, durmica, 4700 pf ±1%, 500VDCW	DM19E472F	Elmenco
*C309	Capacitor, durmica, 3300 pf ±1%, 500VDCW	DM19E332F	Elmenco
*C310	Capacitor, durmica, 2700 pf ±1%, 500VDCW	DM19E272F	Elmenco
*C311	Capacitor, durmica, 2000 pf ±1%, 500VDCW	DM19E202F	Elmenco
*C312	Capacitor, durmica, 1600 pf ±1%, 500VDCW	DM19E162F	Elmenco
*C313	Capacitor, durmica, 1200 pf ±1%, 500VDCW	DM19E122F	Elmenco
*C314	Capacitor, durmica, 910 pf ±1%, 500VDCW	DM19E911F	Elmenco
*C315A	Capacitor, durmica, 2700 pf ±1%, 500VDCW	DM19E272F	Elmenco
*C315B	Capacitor, durmica, 150 pf ±1%, 200VDCW	DM15E151F	Elmenco
**C316	Capacitor, durmica, 7500 pf ±1%, 200VDCW	DM19E752F	Elmenco
**C317	Capacitor, durmica, 6200 pf ±1%, 200VDCW	DM19E622F	Elmenco
**C318	Capacitor, durmica, 4700 pf ±1%, 200VDCW	DM19E472F	Elmenco
**C319	Capacitor, durmica, 3300 pf ±1%, 200VDCW	DM19E332F	Elmenco
**C320	Capacitor, durmica, 2700 pf ±1%, 200VDCW	DM19E272F	Elmenco
**C321	Capacitor, durmica, 2000 pf ±1%, 200VDCW	DM19E202F	Elmenco
**C322	Capacitor, durmica, 1600 pf ±1%, 200VDCW	DM19E162F	Elmenco
**C323	Capacitor, durmica, 1200 pf ±1%, 200VDCW	DM19E122F	Elmenco
**C324	Capacitor, durmica, 910 pf ±1%, 200VDCW	DM19E911F	Elmenco
**C325A	Capacitor, durmica, 2000 pf ±1%, 200VDCW	DM19E202F	Elmenco
**C325B	Capacitor, durmica, 910 pf ±1%, 200VDCW	DM15E911F	Elmenco
CR301	Diode, germanium	1N273	
CR302	Diode, germanium	1N273	
Q301	Transistor, PNP, germanium	2N417	Tungsol
Q302	Transistor, PNP, germanium	2N417	Tungsol

REF DESIG	ITEM	PART NO.	MANUFACTURER
Q303	Transistor, PNP, germanium	2N417	Tungsol
Q304	Transistor, PNP, germanium	2N417	Tungsol
Q305	Transistor, PNP, germanium		Tungsol
R301	Resistor, metal film, 10K±2%, 1/2W	Type C20	Corning
R302	Resistor, metal film, 100K±2%, 1/2W	Type C20	Corning
R303	Resistor, metal film, 3.9K±2%, 1/2W	Type C20	Corning
R304	Resistor, metal film, 100 ohms±2%, 1/2W	Type C20	Corning
R305	Resistor, metal film, 2.2K±2%, 1/2W	Type C20	Corning
R306	Resistor, metal film, 10K±2%, 1/2W	Type C20	Corning
R307	Resistor, comp, 10 ohms ±10%, 1/4W		
R308	Resistor, metal film, 4.7K±2%, 1/2W	Type C20	Corning
R309	Resistor, metal film, 1K±2%, 1/2W	Type C20	Corning
R310	Resistor, metal film, 1K±2%, 1/2W	Type C20	Corning
R311	Resistor, metal film, 1.5K±2%, 1/2W	Type C20	Corning
R312	Resistor, E-Z Trim, 1K, 1/2W	3067P-1-102	Bourns
R313	Resistor, metal film, 1K±2%, 1/2W	Type C20	Corning
R314	Resistor, metal film, 10K±2%, 1/2W	Type C20	Corning
R315	Resistor, metal film, 10K±2%, 1/2W	Type C20	Corning
***R316 thru R335	Resistor, metal film, 390 ohms ±2%, 1/2W	Type C20	Corning
R336	Resistor, variable, dual, 500 ohms each section, 2W	RV-61	Gertsch
R337	Resistor, metal film, 3.3K±2%, 1/2W	Type C20	Corning
R338	Resistor, comp, 100 ohms, ±10%, 1/4W		

* Mounted on A804
** Mounted on A803
*** Mounted on S809

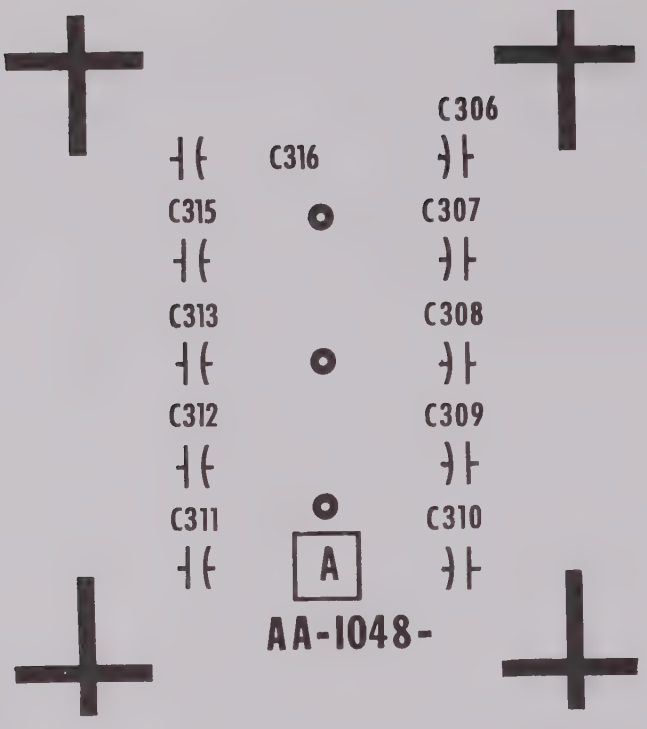


Figure 5-6. Capacitor Assembly, Tuned Amplifier

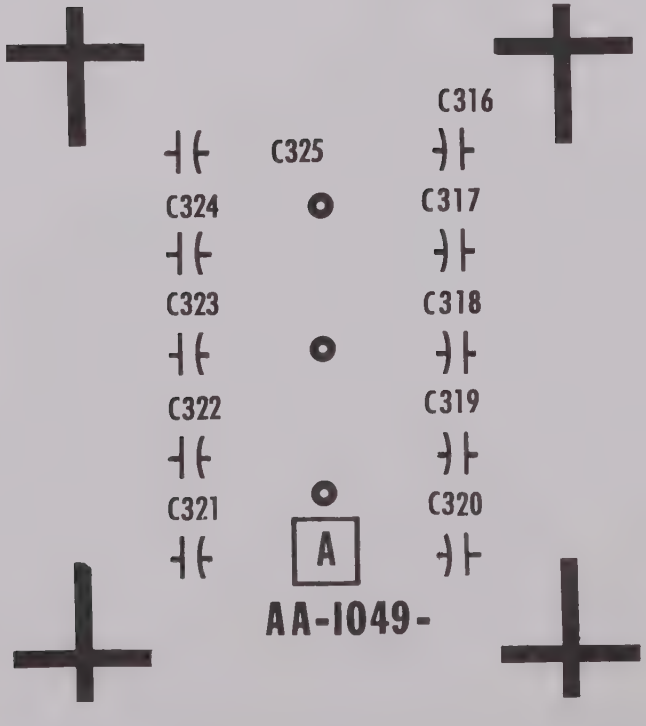


Figure 5-7. Capacitor Assembly, Tuned Amplifier

A805
NULL AMPLIFIER

REF DESIG	ITEM	PART NO.	MANUFACTURER
*C401	Capacitor, electrolytic, 50 uf, 15VDCW	P65AK-125015	MEC
*C402	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-122515	MEC
*C403	Capacitor, durmica, 56 pf, 200VDCW	DM15E560J	Elmenco
*C404	Capacitor, mylar film, 0.047 uf, 50VDCW	MR700	Paktron
*C405	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-122515	MEC
*C406	Capacitor, electrolytic, 500 uf, 3VDCW	P65AP-205003	MEC
*C407	Capacitor, electrolytic, 5 uf, 15VDCW	P65AG-10515	MEC
*C408	Capacitor, electrolytic, 50 uf, 15VDCW	P65AK-125015	MEC
*C409	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-122515	MEC
*C410	Capacitor, durmica, 56 pf, 200VDCW	DM15E560J	Elmenco
*C411	Capacitor, mylar film, 0.047 uf, 50VDCW	MR700	Paktron
*C412	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-122515	MEC
*C413	Capacitor, electrolytic, 500 uf, 3VDCW	P65AP-205003	MEC
*C414	Capacitor, electrolytic, 5 uf, 15VDCW	P65AG-10515	MEC
CR401	Diode, silicon	1N914	Texas Instruments
CR402	Diode, silicon	1N914	Texas Instruments
CR403	Diode, silicon	1N914	Texas Instruments
CR404	Diode, silicon	1N914	Texas Instruments
Q401	Transistor, PNP, germanium	2N417	Tungsol
Q402	Transistor, PNP, germanium	2N417	Tungsol
Q403	Transistor, PNP, germanium	2N417	Tungsol
Q404	Transistor, PNP, germanium	2N417	Tungsol
Q405	Transistor, PNP, germanium	2N417	Tungsol
Q406	Transistor, PNP, germanium	2N417	Tungsol
R401	Resistor, comp, 10K ±10%, 1/2W		
R402	Resistor, comp, 10K ±10%, 1/4W		
R403	Resistor, comp, 2.2K ±10%, 1/4W		
R404	Resistor, comp, 100 ohms ±10%, 1/4W		
R405	Resistor, comp, 330 ohms ±10%, 1/4W		
R406	Resistor, comp, 2.2K ±10%, 1/4W		
R407	Resistor, comp, 220K ±10%, 1/4W		

REF DESIG	ITEM	PART NO.	MANUFACTURER
R408	Resistor, comp, 4.7K ±10%, 1/4W		
R409	Resistor, comp, 33K ±10%, 1/4W		
R410	Resistor, comp, 100 ohms ±10%, 1/4W		
R411	Resistor, comp, 820 ohms ±10%, 1/4W		
R412	Resistor, comp, 470 ohms ±10%, 1/4W		
R413	Resistor, comp, 4.7K ±10%, 1/4W		
R414	Resistor, comp, 10K ±10%, 1/4W		
R415	Resistor, comp, 10K ±10%, 1/4W		
R416	Resistor, comp, 2.2K ±10%, 1/4W		
R417	Resistor, comp, 100 ohms ±10%, 1/4W		
R418	Resistor, comp, 330 ohms ±10%, 1/4W		
R419	Resistor, comp, 2.2K ±10%, 1/4W		
R420	Resistor, comp, 220K ±10%, 1/4W		
R421	Resistor, comp, 4.7K ±10%, 1/4W		
R422	Resistor, comp, 33K ±10%, 1/4W		
R423	Resistor, comp, 100 homs ±10%, 1/4W		
R424	Resistor, comp, 820 ohms ±10%, 1/4W		
R425	Resistor, comp, 470 ohms ±10%, 1/4W		
R426	Resistor, comp, 4.7K ±10%, 1/4W		

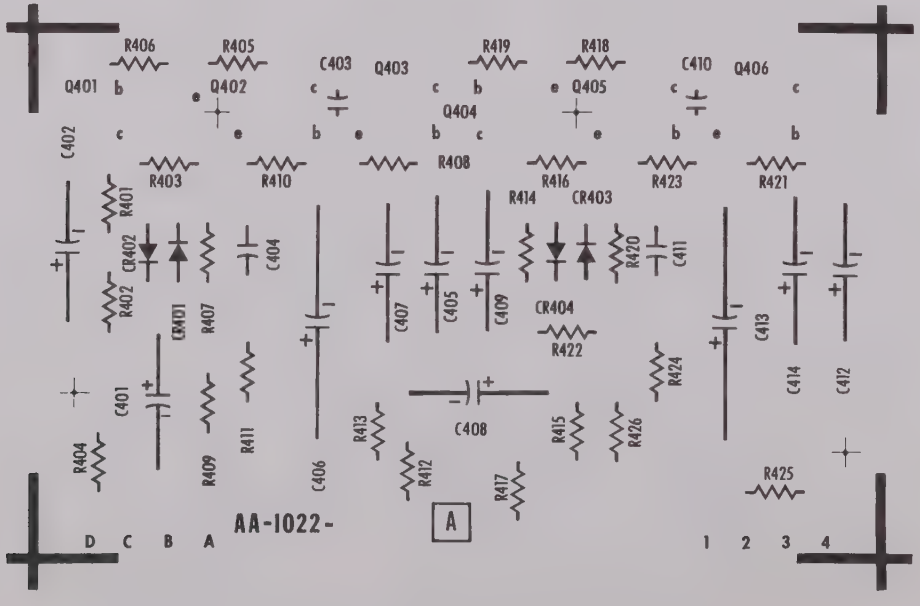


Figure 5-8. Null Amplifier

A806
NULL AMPLIFIER & PHASE DETECTOR

REF DESIG	ITEM	PART NO.	MANUFACTURER
C415	Capacitor, electrolytic, 50 uf, 15VDCW	P65AK-125015	MEC
C416	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-122515	MEC
C417	Capacitor, durmica, 56 pf, 200VDCW	DM15E560J	Elmenco
C418	Capacitor, mylar film, 0.047 uf, 50VDCW	MR700	Paktron
C419	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-122515	MEC
C420	Capacitor, electrolytic, 500 uf, 3VDCW	P65AP-205003	MEC
C421	Capacitor, electrolytic, 5 uf, 15VDCW	P65AG-10515	MEC
C422	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-122515	MEC
CR405	Diode, silicon	1N914	Texas Instruments
CR406	Diode, silicon	1N914	Texas Instruments
CR407	Diode, silicon	1N457	
CR408	Diode, silicon	1N457	
CR409	Diode, silicon	1N457	
CR410	Diode, silicon	1N457	
Q407	Transistor, PNP, germanium	2N417	Tungsol
Q408	Transistor, PNP, germanium	2N417	Tungsol
Q409	Transistor, PNP, germanium	2N417	Tungsol
R427	Resistor, comp, 10K ±10%, 1/4W		
R428	Resistor, comp, 10K ±10%, 1/4W		
R429	Resistor, comp, 2.2K ±10%, 1/4W		
R430	Resistor, comp, 100 ohms ±10%, 1/4W		
R431	Resistor, comp, 330 ohms ±10%, 1/4W		
R432	Resistor, comp, 2.2K ±10%, 1/4W		
R433	Resistor, comp, 220K ±10%, 1/4W		
R434	Resistor, comp, 4.7K ±10%, 1/4W		
R435	Resistor, comp, 33K ±10%, 1/4W		
R436	Resistor, comp, 100 ohms ±10%, 1/4W		
R437	Resistor, comp, 820 ohms ±10%, 1/4W		
R438	Resistor, comp, 470 ohms ±10%, 1/4W		
R439	Resistor, comp, 4.7K ±10%, 1/4W		

REF DESIG	ITEM	PART NO.	MANUFACTURER
R440	Resistor, comp, 22K ±10%, 1/4W		
R441	Resistor, comp, 2.2K ± 10%, 1/4W		
R442	Resistor, comp, 2.2K ± 10%, 1/4W		
R443	Resistor, comp, 22K ±10%, 1/4W		
R444	Resistor, comp, 2.2K ±10%, 1/4W		
R445	Resistor, comp, 2.2K ±10%, 1/4W		
T401	Transformer	TA-255	Gertsch

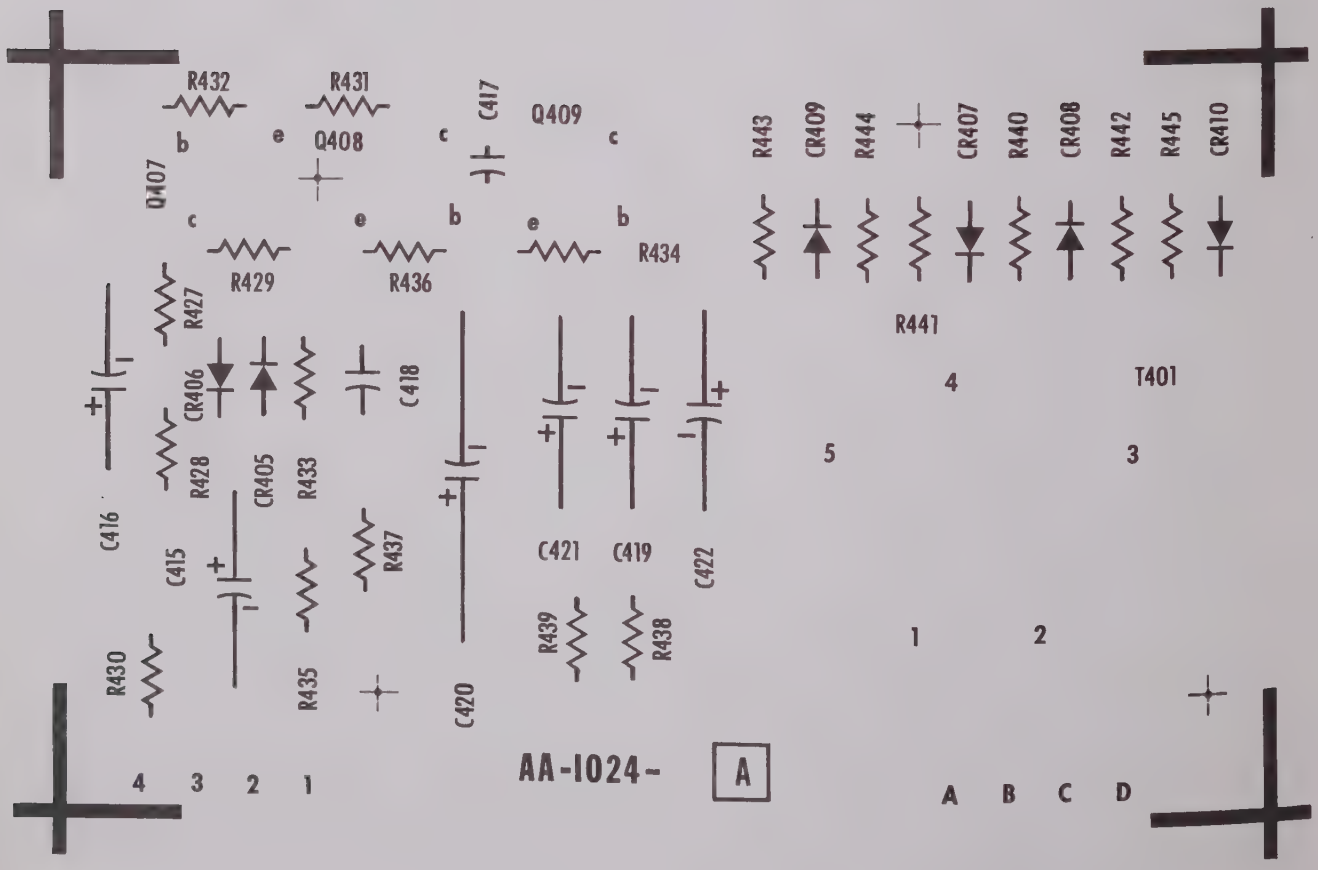


Figure 5-9. Null Amplifier and Phase Detector

A807, A808, A809
QUADRATURE GENERATOR

REF DESIG	ITEM	PART NO.	MANUFACTURER
C502	Capacitor, electrolytic, 5.0 uf, 150VDCW	TE1504	Sprague
C503	Capacitor, disc, 0.01 uf, 300VDCW	811Z5U103Z	Erie
C504	Capacitor, durmica, 56 pf, 200VDCW	DM15E560J	Elmenco
C505	Capacitor, durmica, 330 pf, 200VDCW	DM15E331J	Elmenco
*C506	Capacitor, polystyrene, 890 pf, 100VDCW	RT8900H1A	Reliable
*C507	Capacitor, polystyrene, 0.00118 uf, 100VDCW	RT1181H1A	Reliable
*C508	Capacitor, polystyrene, 0.00154 uf, 100VDCW	RT1541H1A	Reliable
*C509	Capacitor, polystyrene, 0.002 uf, 100VDCW	RT202H1A	Reliable
*C510	Capacitor, polystyrene, 0.00267 uf, 100VDCW	RT2671H1A	Reliable
*C511	Capacitor, polystyrene, 0.00348 uf, 100VDCW	RT3481H1A	Reliable
*C512	Capacitor, polystyrene, 0.00452 uf, 100VDCW	RT4521H1A	Reliable
*C513	Capacitor, polystyrene, 0.0059 uf, 100VDCW	RT592H1A	Reliable
*C514	Capacitor, polystyrene, 0.0077 uf, 100VDCW	RT772H1A	Reliable
*C515	Capacitor, polystyrene, 0.01 uf, 100VDCW	RT103H1A	Reliable
C516	Capacitor, mylar, 4 uf, 200VDCW	HRC168	Reliable
C517	Capacitor, electrolytic, 5 uf, 150VDCW	TE1504	Sprague
C518	Capacitor, disc, 0.01 uf, 300VDCW	811Z5U103Z	Erie
C519	Capacitor, durmica, 130 pf, 200VDCW	DM15E131J	Elmenco
C520	Capacitor, durmica, 2 pf, 200VDCW	DM15E020J	Elmenco
C521	Capacitor, mylar, 0.5 uf, 200VDCW	VF504M2A	Reliable
C522	Capacitor, mylar, 4 uf, 200VDCW	HRC168	Reliable
CR501	Diode, silicon	1N457	
CR502	Diode, silicon	1N457	
**R503	Resistor, variable, 6K, 2W	RV-61	Gertsch
**R505	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning
**R506	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning

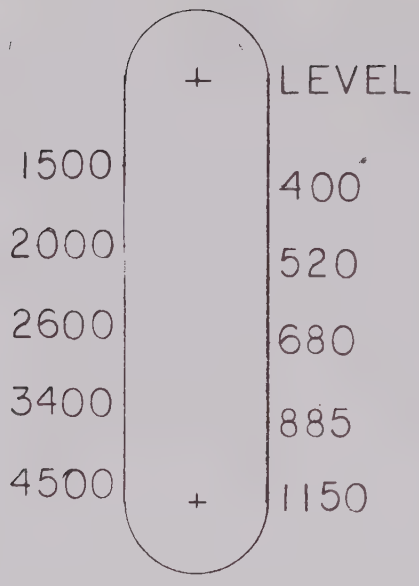


Figure 5-10. Resistor Assembly, Quadrature Generator

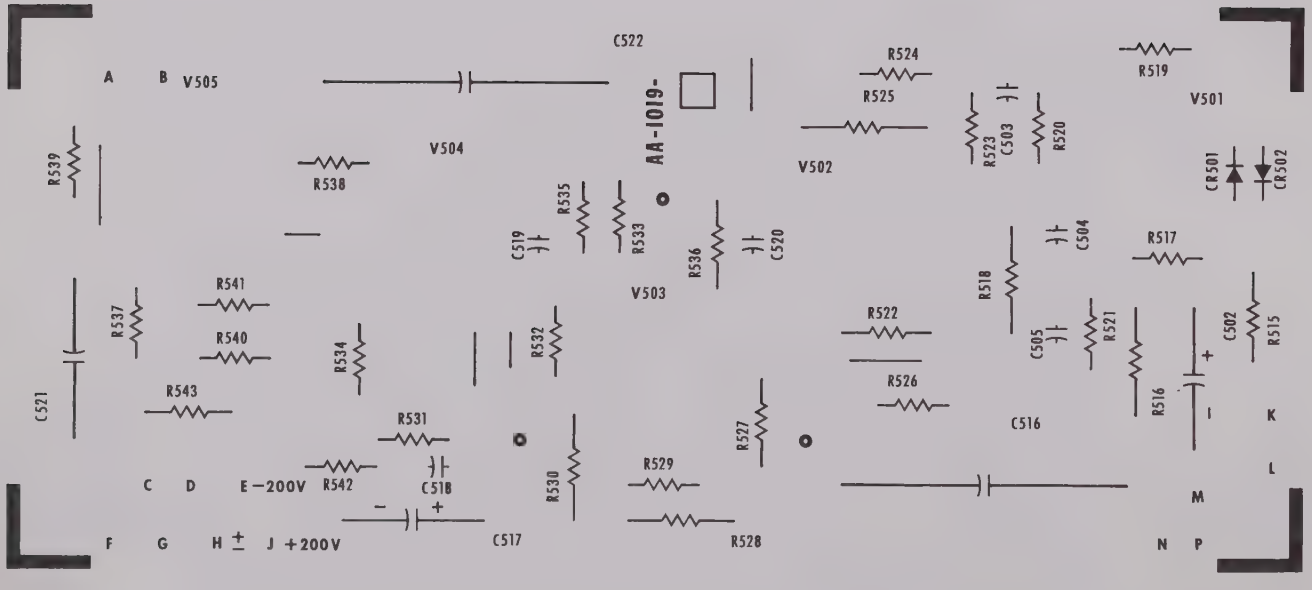


Figure 5-11. Quadrature Generator

REF DESIG	ITEM	PART NO.	MANUFACTURER
**R507	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning
**R508	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning
**R509	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning
**R510	Resistor, film, 4.7K ±2%, 1/2W	Type C07	Corning
**R511	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning
**R512	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning
**R513	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning
**R514	Resistor, film, 4.3K ±2%, 1/2W	Type C07	Corning
R515	Resistor, deposited carbon, 130K ±1%, 1/4W	Type MDP	IRC
R516	Resistor, comp, 47K ±10%, 1W		
R517	Resistor, comp, 33K ±10%, 1/2W		
R518	Resistor, comp, 22K ±10%, 1W		
R519	Resistor, comp, 100 ohms ±10%, 1/2W		
R520	Resistor, comp, 1 meg ± 10%, 1/2W		
R521	Resistor, comp, 12K ±10%, 1/2W		
R522	Resistor, comp, 100 ohms ±10%, 1/2W		
R523	Resistor, comp, 100 ohms ±10%, 1/2W		
R524	Resistor, comp, 2.2 meg ±10%, 1/2W		
R525	Resistor, comp, 39K ±10%, 2W		
R526	Resistor, comp, 1 meg ±10%, 1/2W		
R527	Resistor, deposited carbon, 150K ±1%, 1/4W	Type MDB	IRC
R528	Resistor, comp, 47K ±10%, 1W		
R529	Resistor, comp, 33K ±10%, 1/2W		
R530	Resistor, comp, 22K ±10%, 1W		
R531	Resistor, comp, 820K ±10%, 1/2W		
R532	Resistor, comp, 10K ±10%, 1/2W		
R533	Resistor, comp, 100 ohms ±10%, 1/2W		
R534	Resistor, comp, 100 ohms ±10%, 1/2W		
R535	Resistor, comp, 12K ±10%, 1/2W		
R536	Resistor, deposited carbon, 150K ±1%, 1/4W		

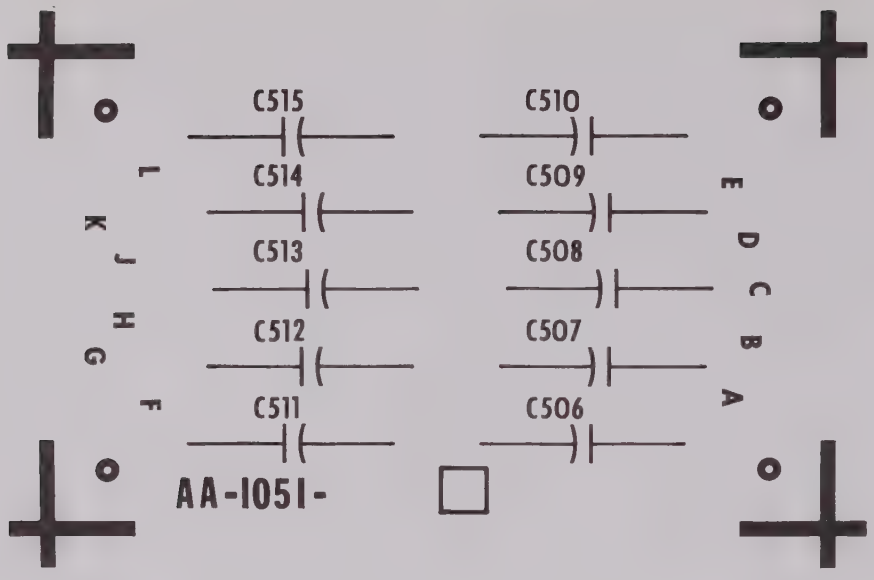


Figure 5-12. Capacitor Assembly, Quadrature Generator

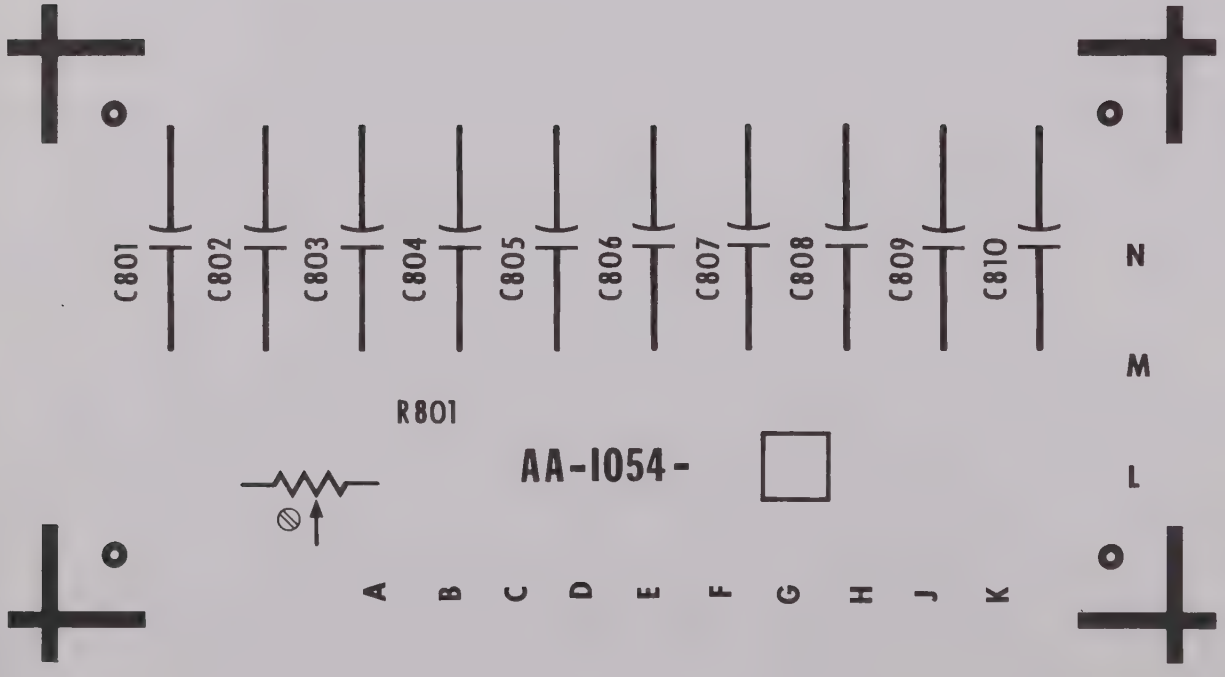


Figure 5-13. Adjustment Assembly, Unity Cal

REF DESIG	ITEM	PART NO.	MANUFACTURER
R537	Resistor, comp, 220K ±10%, 1/2W		
R538	Resistor, comp, 100 ohms ±10%, 1/2W		
R539	Resistor, comp, 100 ohms ±10%, 1/2W		
R540	Resistor, comp, 15K ±10%, 1/2W		
R541	Resistor, comp, 1K ±10%, 1/2W		
R542	Resistor, comp, 1.5 meg ± 10%, 1/2W		
R543	Resistor, comp, 100K ±10%, 1/2W		
#R544	Resistor, comp, 1K ±10%, 1/4W		
#R545	Resistor, comp, 1K ±10%, 1/4W		
#R546	Resistor, E-Z Trim, 5K	3067S-5K	Bourns
#R547	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R548	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R549	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R550	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R551	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R552	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R553	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R554	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R555	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
#R556	Resistor, E-Z Trim, 20K	3068S-20K	Bourns
V501	Tube, low-noise pentode	7722	Siemans
V502	Tube, twin triode	12AT7	
V503	Tube, low-noise pentode	7722	Siemans
V504	Tube, triode	6S4	
V505	Tube, twin triode	12AT7	
XV501 thru XV505	Socket, tube, 9 pin	P465	Methode
	Shield, tube (2 required)	CFT6MD	Coolfin
	Shield, tube (3 required)	CFT6LD	Coolfin

* Mounted on A809
** Mounted on S808
\# Mounted on A807

A811
LEVEL COMPARISON

REF DESIG	ITEM	PART NO.	MANUFACTURER
C701	Capacitor, electrolytic, 10 uf, 15VDCW	P65AG-101015	MEC
C702	Capacitor, electrolytic, 10 uf, 15VDCW	P65AG-101015	MEC
C703	Capacitor, mylar, 0.47 uf, 50VDCW	WS4474	Westcap
CR701	Diode, germanium	1N273	Transitron
CR702	Diode, germanium	1N273	Transitron
CR703	Diode, zener	1N1509	International
CR704	Diode, germanium	1N273	Transitron
CR705	Diode, germanium	1N273	Transitron
R701	Resistor, comp, 270 ohms, ±10%, 1/4W		
R702	Resistor, comp, 27K ±10%, 1/4W		
R703	Resistor, comp, 10K ±10%, 1/4W		
R704	Resistor, comp, 100 ohms ±10%, 1/4W		
R705	Resistor, E-Z Trim, 500 ohms	3067A-501	Bourns
R706	Resistor, comp, 1K ±10%, 1/4W		
R707	Resistor, comp, 10 ohms ±10%, 1/2W		
R708	Resistor, comp, 3.3K ±10%, 1/2W		

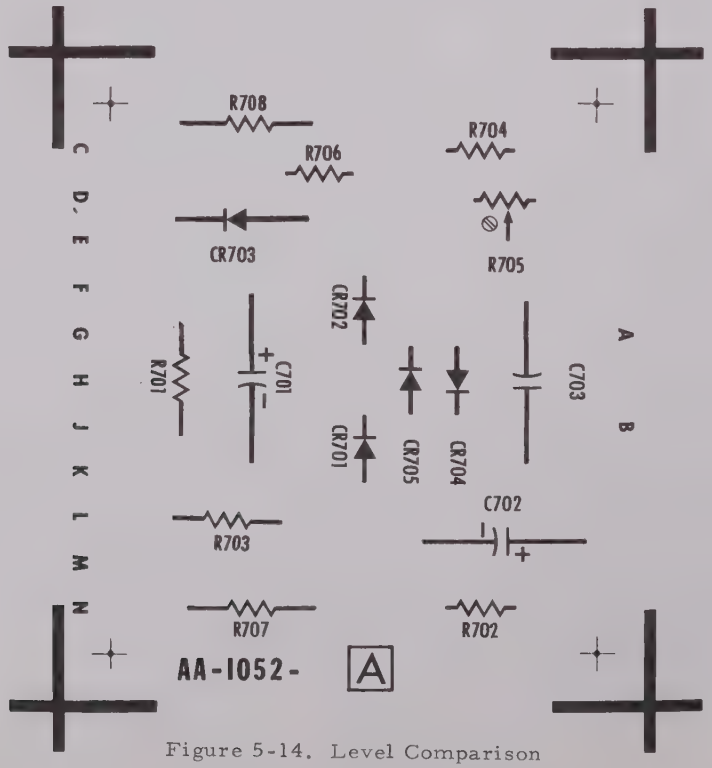


Figure 5-14. Level Comparison

A812
REFERENCE AMPLIFIER

REF DESIG	ITEM	PART NO.	MANUFACTURER
C601	Capacitor, electrolytic, 25 uf, 50VDCW	P65HN162550	MEC
C602	Capacitor, trimmer, 2 to 8 pf	NPO538-000	Erie
C603	Capacitor, electrolytic, 25 uf, 15VDCW	P65AG-122515	MEC
C604	Capacitor, durmica, 240 pf, 250VDCW	DM15E241J	Elmenco
C605	Capacitor, electrolytic, 25 uf, 50VDCW	P65AN-162550	MEC
C606	Capacitor, trimmer, 2 to 8 pf	NPO538-000	Erie
C607	Capacitor, mylar film, 0.47 uf, 50VDCW	WS4474	Westcap
C608	Capacitor, electrolytic, 100 uf, 3VDCW	P65AK-121003	MEC
C609	Capacitor, mica, 4300 pf ±5%	DM19E432J	Elmenco
C610	Capacitor, electrolytic, 25 uf, 50VDCW	P65AN-162550	MEC
CR601	Diode, silicon	1N457	
CR602	Diode, silicon	1N457	
Q601	Transistor, PNP, germanium	2N417	Tungsol
Q602	Transistor, PNP, germanium	2N1188	Motorola
Q603	Transistor, PNP, germanium	2N1188	Motorola
R601	Resistor, metal film, 61.9K ±1%, 1/4W	Type N65	Corning
R602	Resistor, metal film, 332K ±1%, 1/4W	Type N65	Corning
R603	Resistor, comp, 1.5 meg ±10%, 1/4W		
R604	Resistor, comp, 100 ohms ±10%, 1/4W		
R605	Resistor, comp, 330 ohms ±10%, 1/4W		
R606	Resistor, comp, 4.7K ±10%, 1/4W		
R607	Resistor, comp, 1K ±10%, 1/4W		
R608	Resistor, comp, 6.8K ±10%, 1/4W		
R609	Resistor, comp, 100 ohms ±10%, 1/4W		
R610	Resistor, comp, 820 ohms ±10%, 1/4W		
R611	Resistor, comp, 3.3 meg ±10%, 1/4W		
R612	Resistor, metal film, 44.2K ±1%, 1/4W		
*R613	Resistor, variable, 2K, 2W	RV-61-1	Gertsch
*R614 thru R625	Resistor, comp, 470 ohms ±10%, 1/4W		
R626	Resistor, E-Z Trim, 1K	3067P-1-1K	Bourns

* Mounted on S802

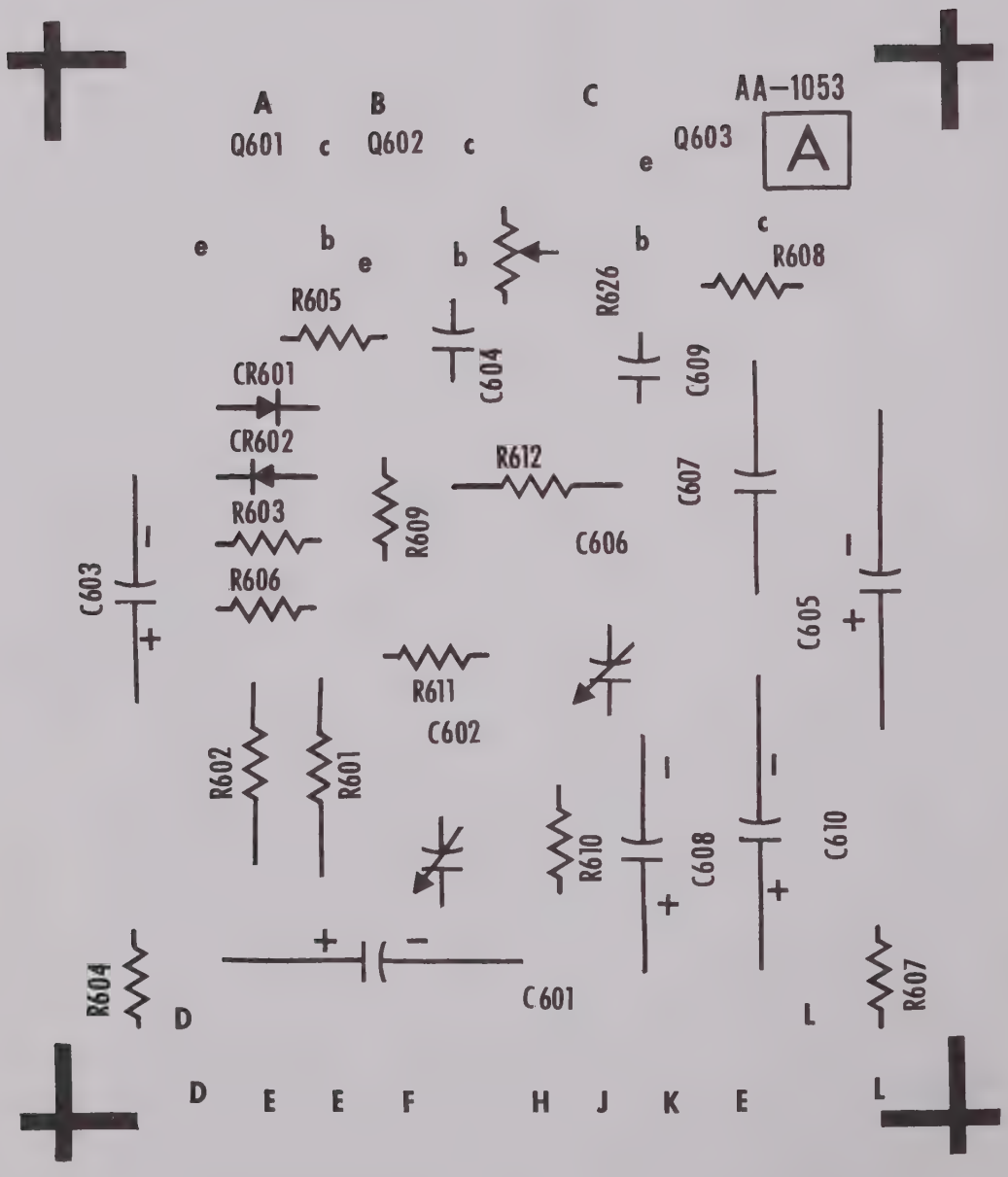


Figure 5-15. Reference Amplifier

A813
POWER SUPPLY

REF DESIG	ITEM	PART NO.	MANUFACTURER
A101	Bridge Rectifier	SB2	Semtech
A102	Bridge Rectifier	SB2	Semtech
A103	Bridge Rectifier	SB8	Semtech
C101	Capacitor, electrolytic, 50 uf, 50VDCW	TE1307	Sprague
C102	Capacitor, electrolytic, 50 uf, 15VDCW	TE1160	Sprague
C103	Capacitor, electrolytic, 25uf, 25VDCW	TE1207	Sprague
C104	Capacitor, electrolytic, 150 uf, 150VDCW	TVA1422	Sprague
C105	Capacitor, electrolytic, 25 uf, 25VDCW	TE1207	Sprague
C106	Capacitor, electrolytic, 50 uf, 25VDCW	TE1209	Sprague
C107	Capacitor, electrolytic, 50 uf, 15VDCW	TE1160	Sprague
C108	Capacitor, electrolytic, 40 uf, 350VDCW	TVA1611	Sprague
C109	Capacitor, electrolytic, 40 uf, 350VDCW	TVA1611	Sprague
C110	Capacitor, electrolytic, 40 uf, 350VDCW	TVA1611	Sprague
C111	Capacitor, electrolytic, 40 uf, 350VDCW	TVA1611	Sprague
CR101	Diode, zener, 12V ±5%, 1W	1N3022B	Motorola
CR102	Diode, zener, 18V ±5%, 1W	1N3026B	Motorola
CR103	Diode, zener, 12V ±5%, 1W	1N3022B	Motorola
CR104	Diode, zener, 6.8V ±5%, 1W	1N3016B	Motorola
CR105	Diode, zener, 200V ±5%, 10W	1N3015B	Motorola
CR106	Diode, zener, 200V ±5%, 10W	1N3015RB	Motorola
J101	Connector, receptacle, 5 pin	126-218	Amphenol
J102	Connector, receptacle, 9 pin	126-221	Amphenol
J103	Connector, BNC		
J104	Connector	MDR07-19S-059	Deutsch
P101	Connector, 5 pin male	126-217	Amphenol
P102	Connector, 9 pin male	126-220	Amphenol
P103	Connector, BNC		
P104	Connector	MDR07-19P-059	Deutsch
Q101	Transistor, PNP, germanium	2N1363	
Q102	Transistor, PNP, germanium	2N1188	

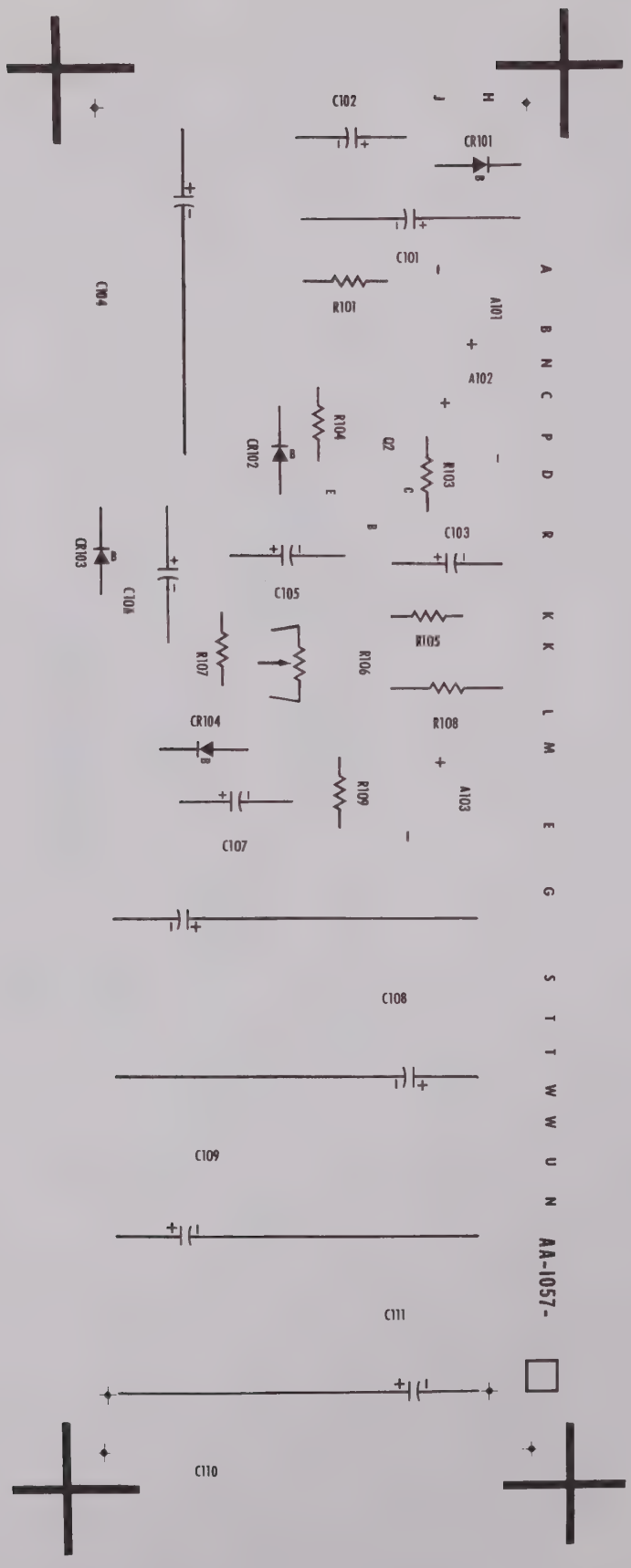


Figure 5-16. Power Supply

REF DESIG	ITEM	PART NO.	MANUFACTURER
R101	Resistor, comp, 1.5K ±10%, 1W		
R102	Resistor, wirewound, 25 ohms, 10W	MOR-10-25	Troohm
R103	Resistor, comp, 4.7K ±10%, 1/2W		
R104	Resistor, comp, 6.8K ±10%, 1/2W		
R105	Resistor, comp, 3.9K ±10%, 1/2W		
R106	Resistor, variable, 1K ±20%, 2W	Type HHH-2	Mel-Rain
R107	Resistor, comp, 3.9K ±10%, 1/2W		
R108	Resistor, comp, 680 ohms, ±10%, 2W		
R109	Resistor, comp, 1K ±10%, 1/2W		
R110	Resistor, wirewound, 2K ±10%, 10W	MOR-10-2K	Tru-Ohm
R111	Resistor, wirewound, 2.5K ±10%, 10W	MOR-10-2.5K	Tru-Ohm
S101	Switch, slide, DPDT	4633	Muter
S102	Switch, slide, DPDT	4603-A2	Muter
T101	Transformer	TP17	Triad
T102	Transformer	TP16A	Triad
W101	Power Cord	17406-S	Belden

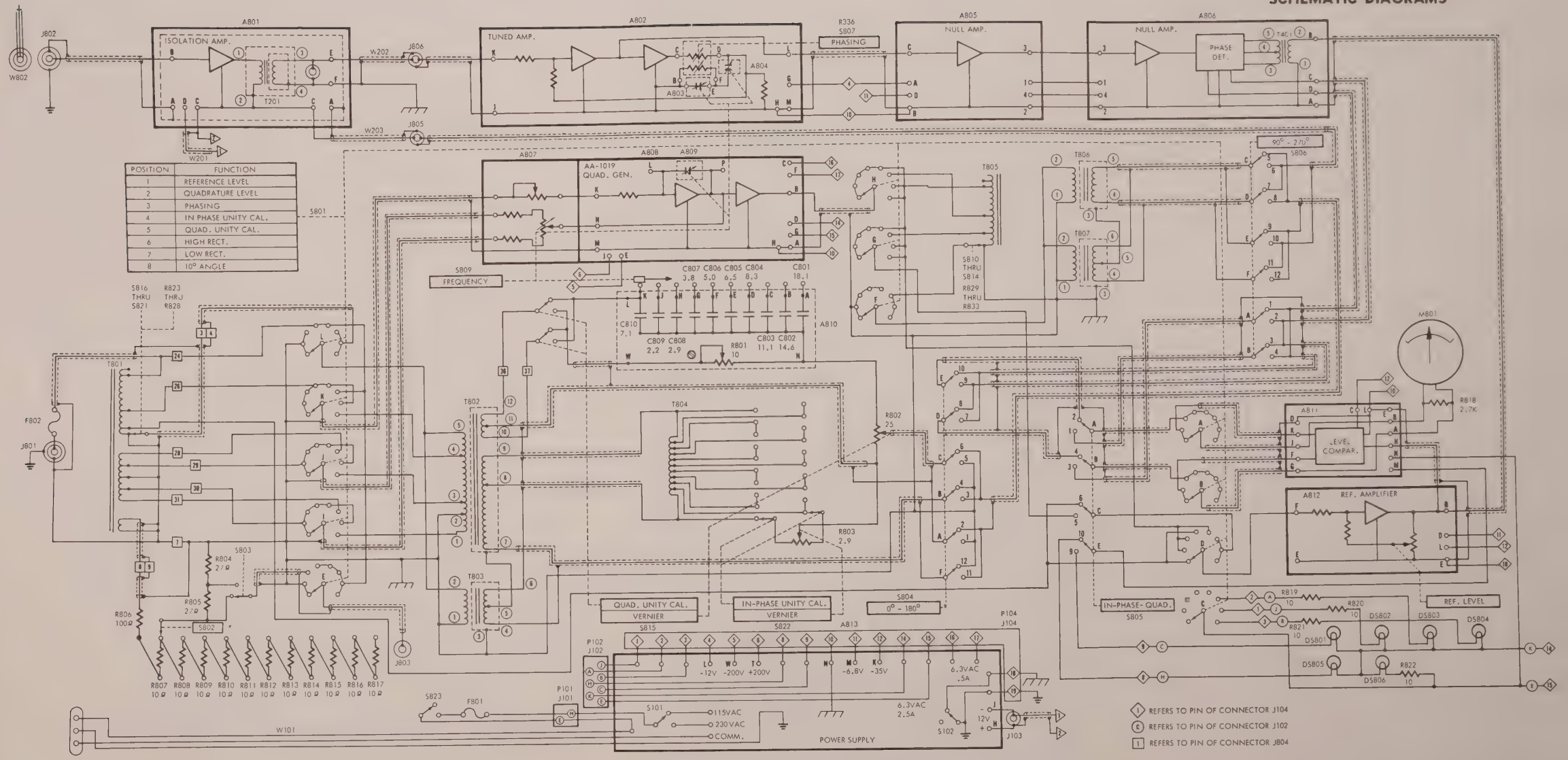


Figure 6-1. Chassis Interconnection Diagram and Schematic

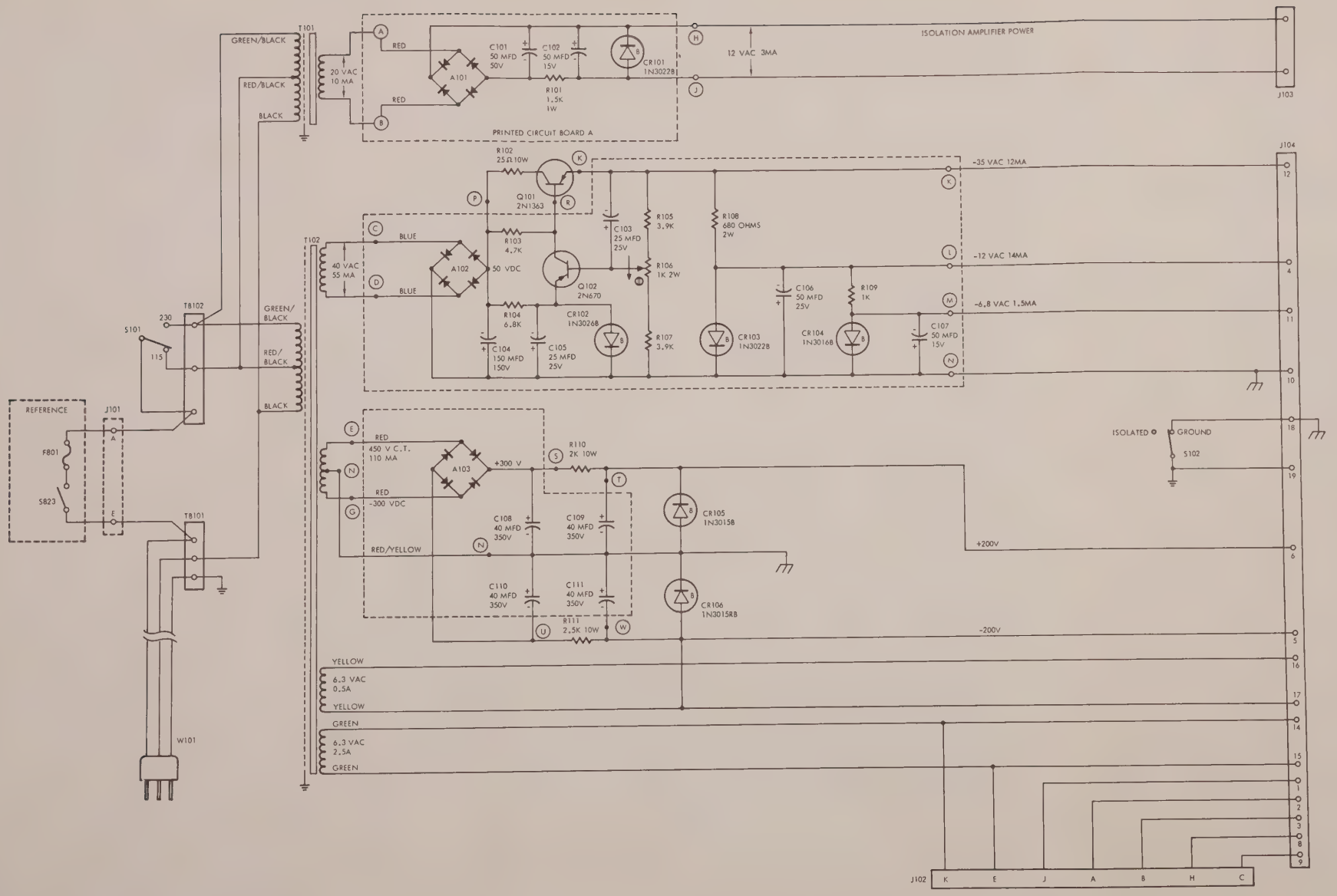


Figure 6-2. Power Supply Schematic

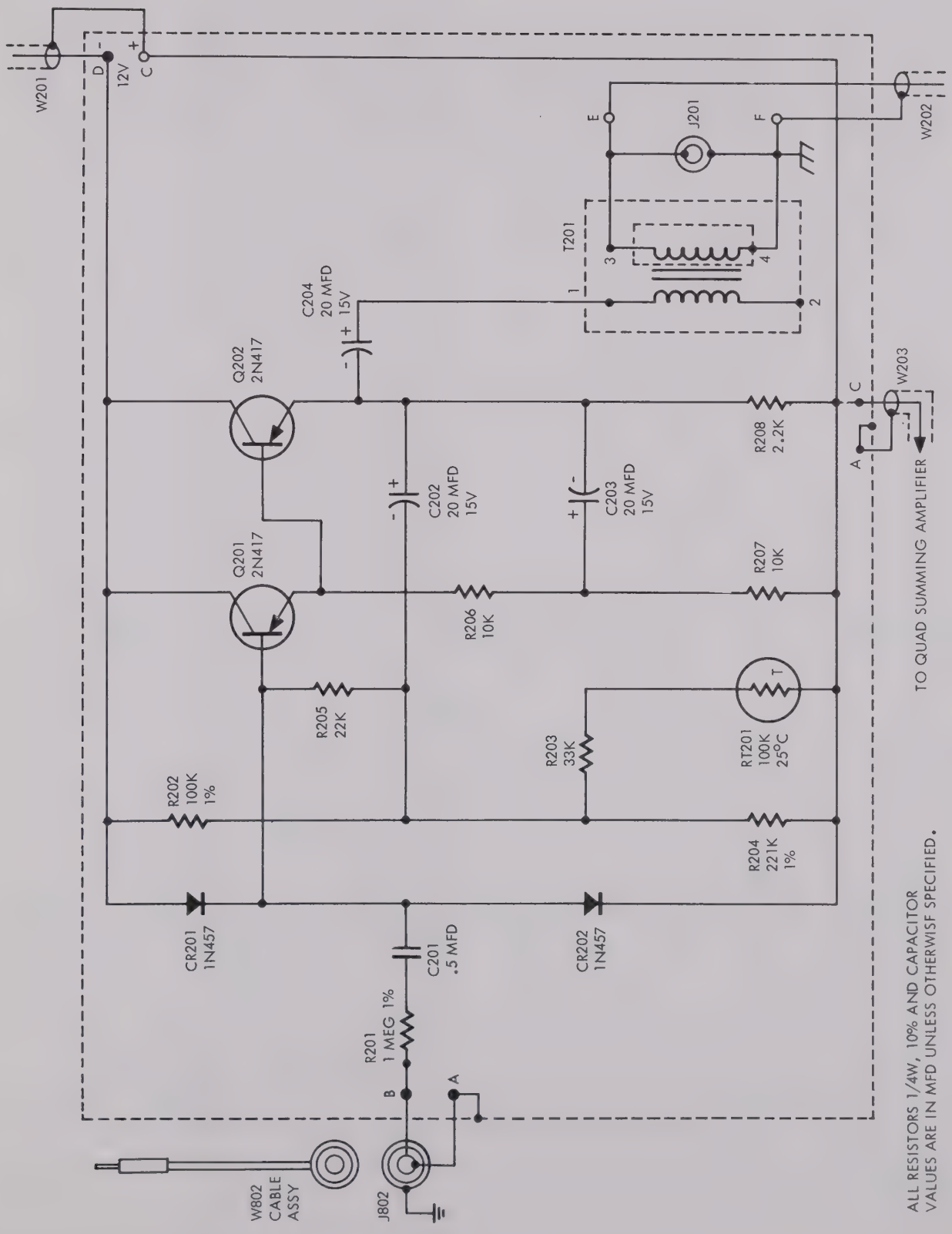


Figure 6-3. Isolation Amplifier Schematic

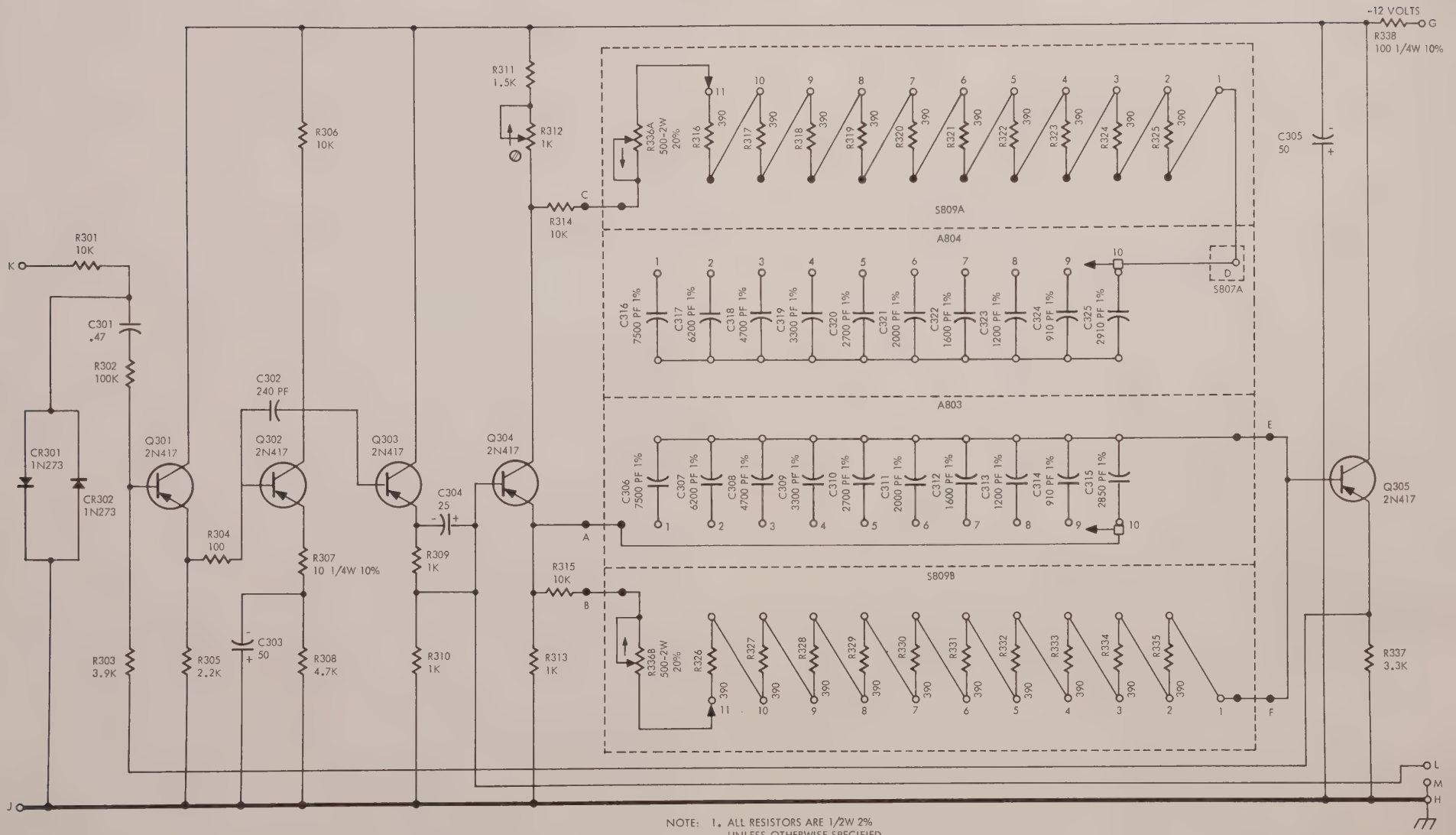


Figure 6-4. Tuned Amplifier Schematic

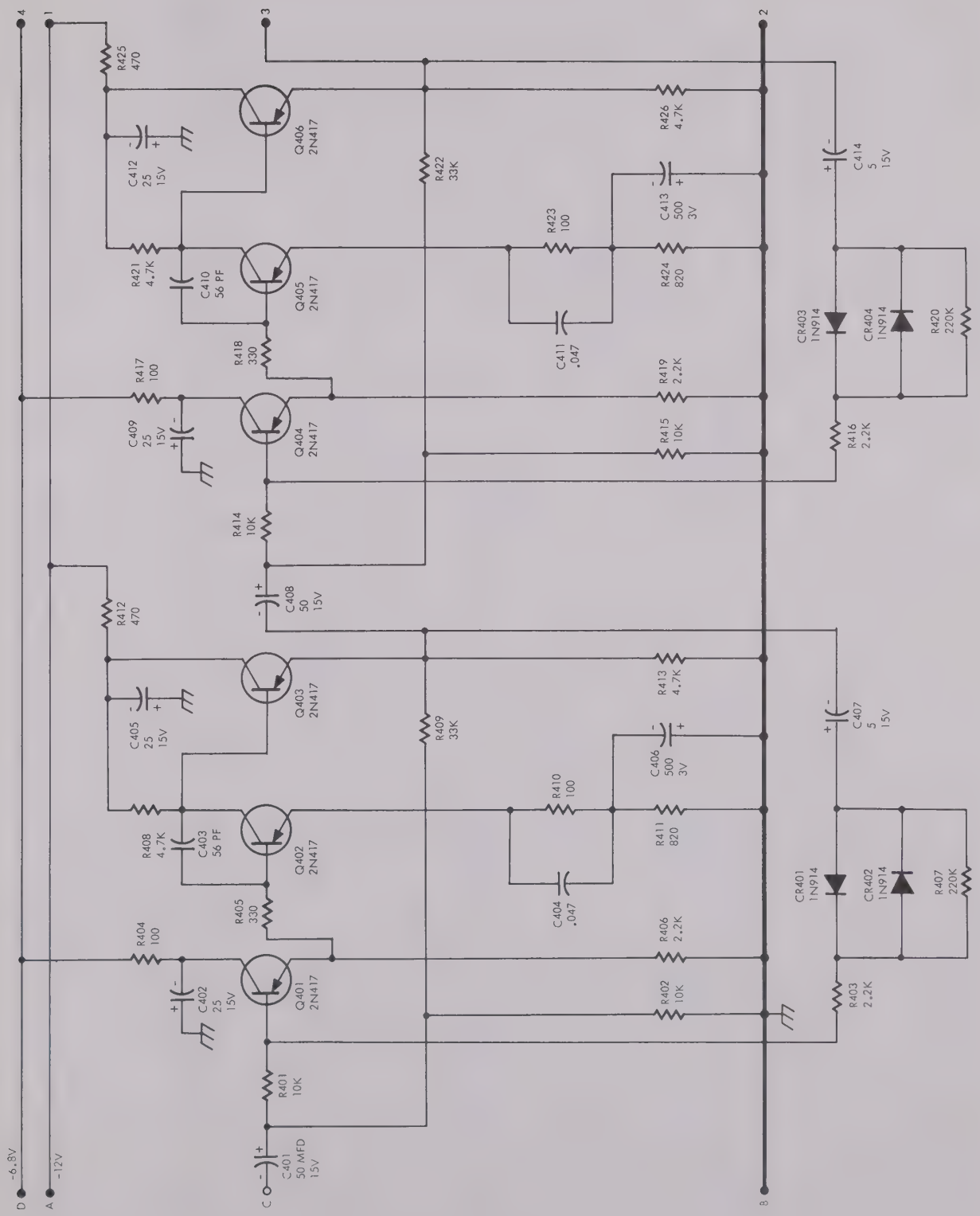


Figure 6-5. Null Amplifier Schematic (Sheet 1 of 2)

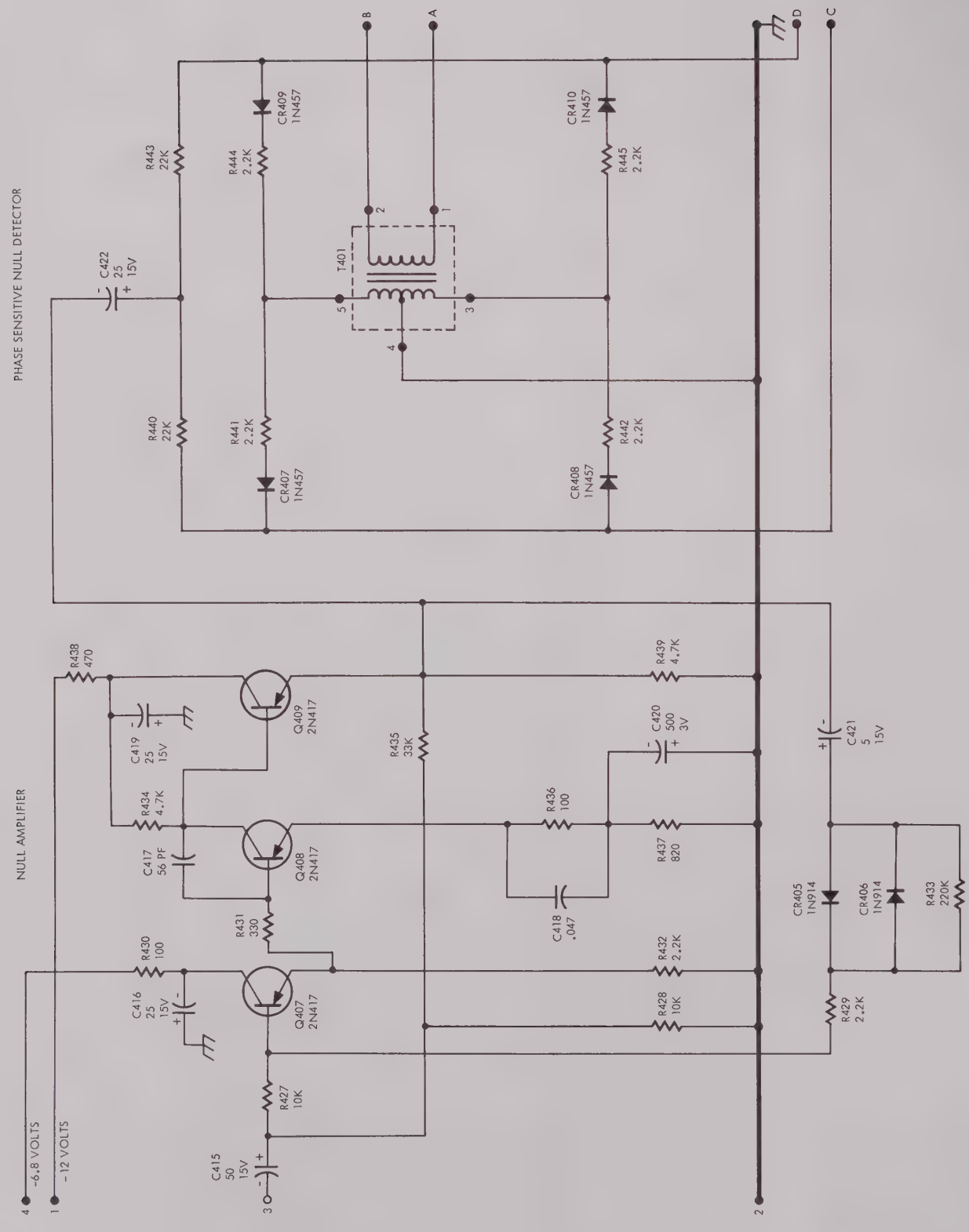


Figure 6-5. Null Amplifier Schematic (Sheet 2 of 2)

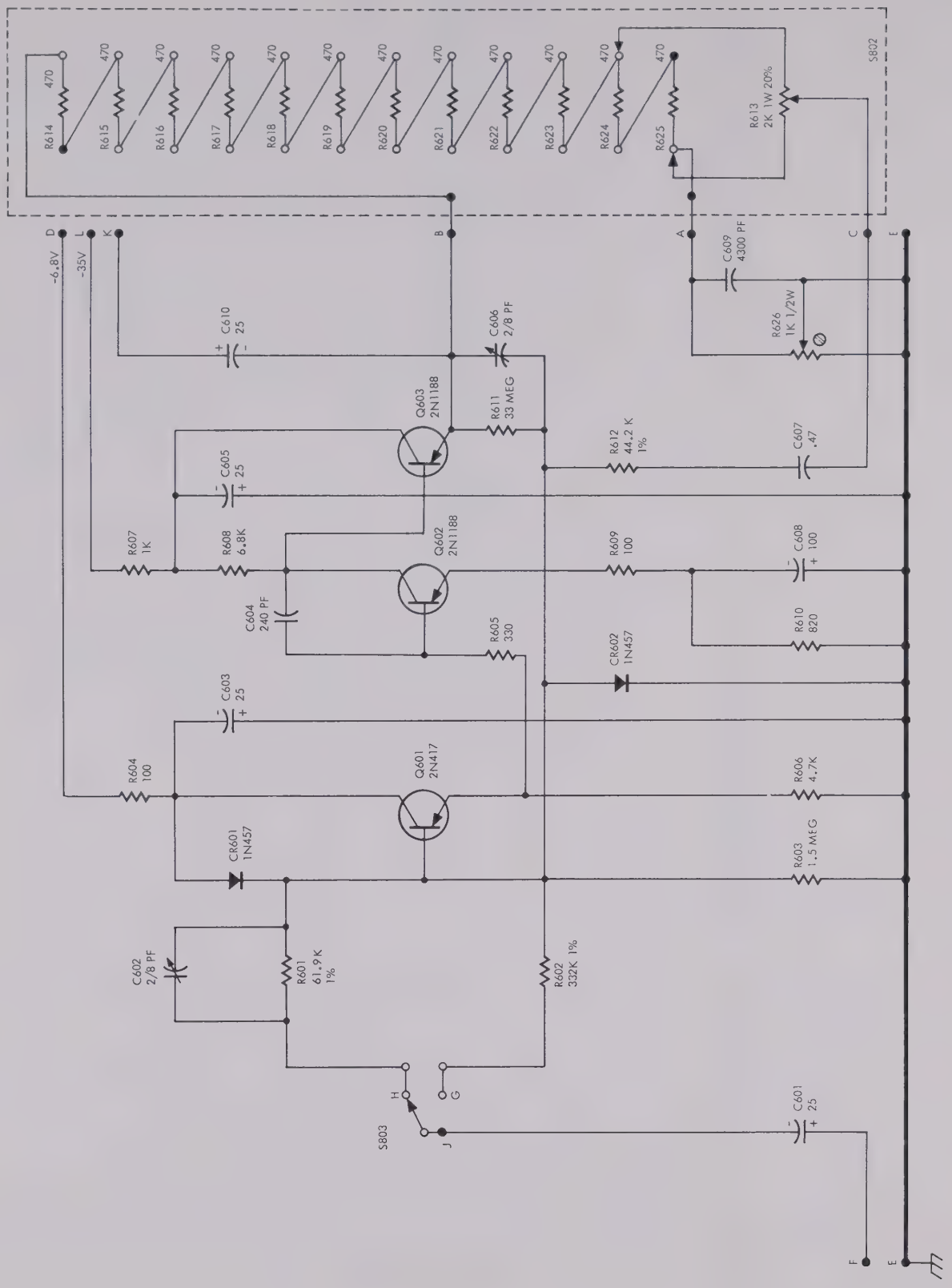
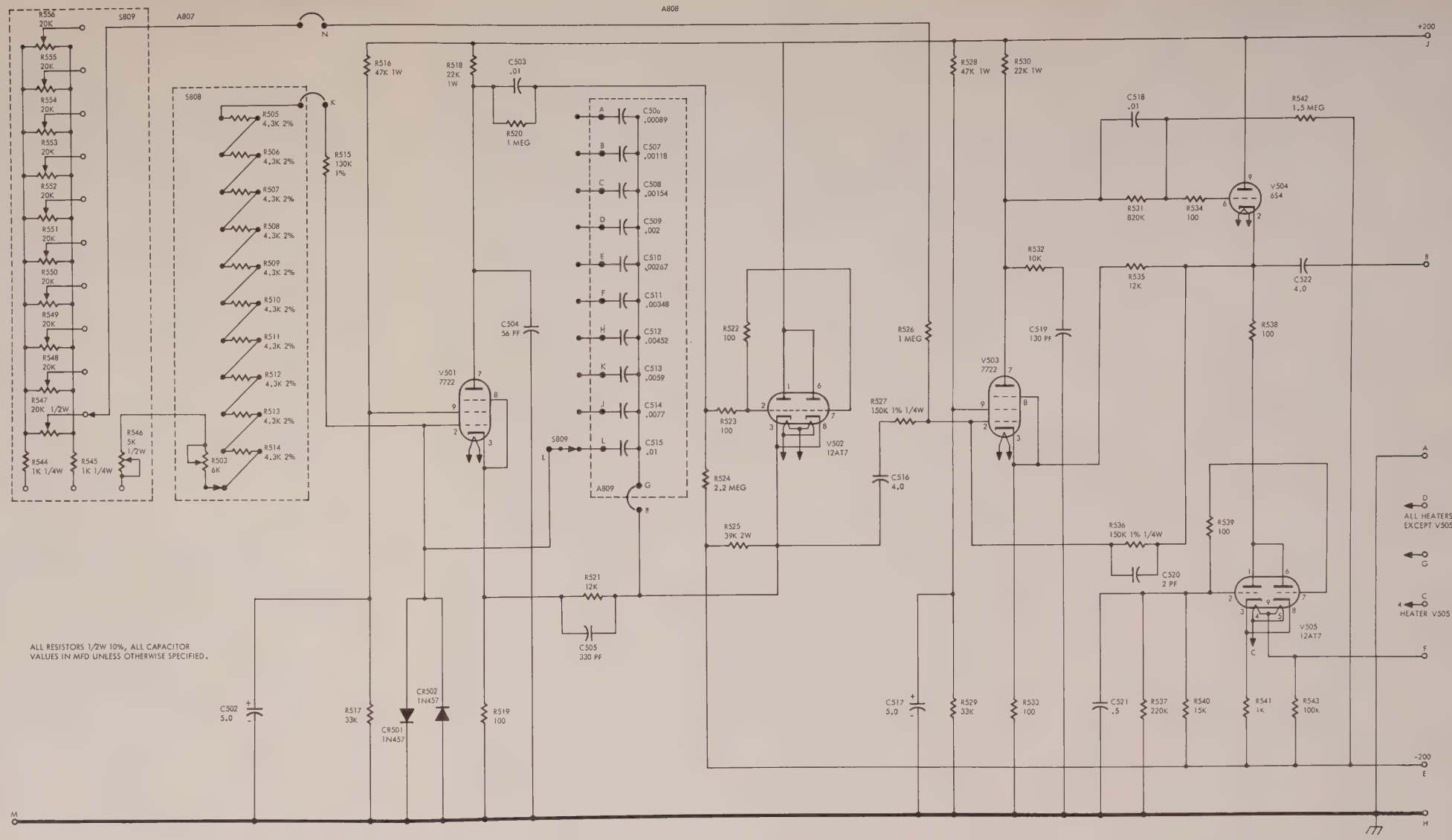
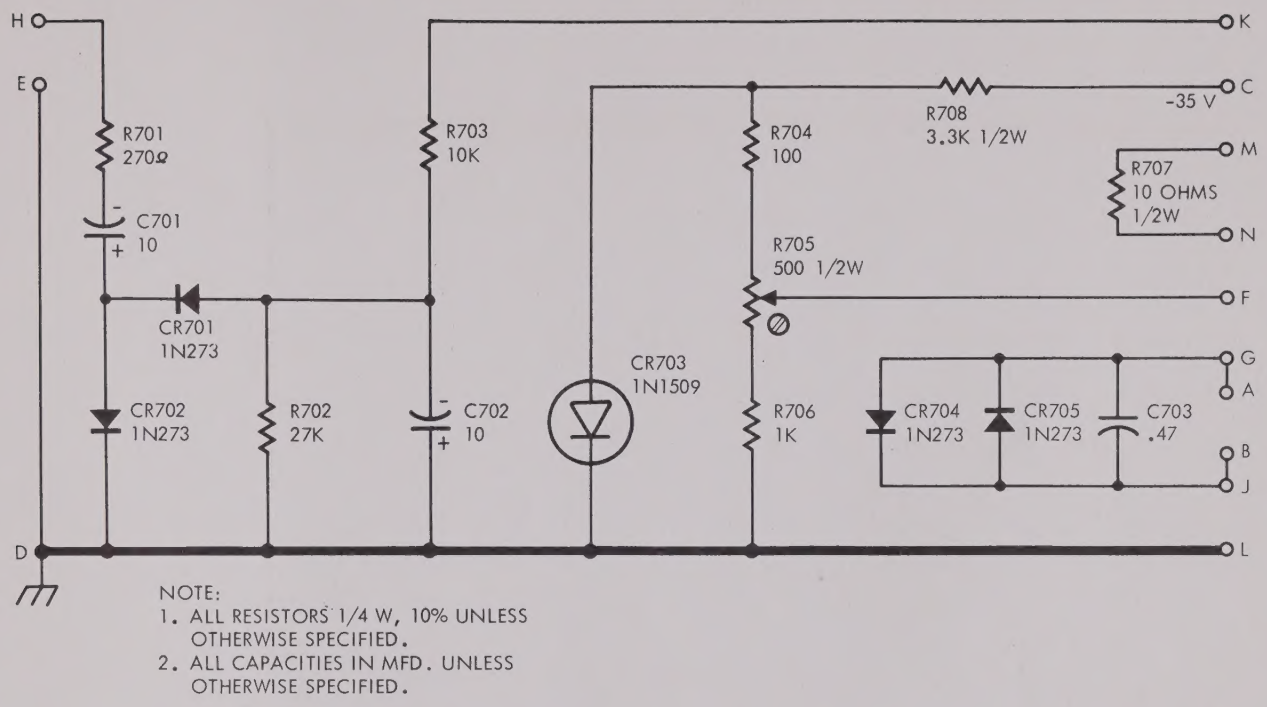


Figure 6-7. Reference Amplifier



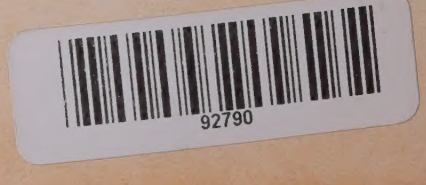
ALL RESISTORS 1/2W 10%, ALL CAPACITOR VALUES IN MFD UNLESS OTHERWISE SPECIFIED.

Figure 6-6. Quadrature Generator



NOTE:
1. ALL RESISTORS 1/4 W, 10% UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITIES IN MFD. UNLESS OTHERWISE SPECIFIED.

Figure 6-8. Level Comparison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